

Planning and Implementing Qualitative Interviewing to Extract Students' Analogical Reasoning

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ABSTRACT

Research on students' analogical reasoning is not easy to conduct because the cognitive processes occurring in the minds of the students cannot be observed directly. As such, the complexity of this study required adequate foundation before it was carried out. The objective of the research is to explore the analogical reasoning of biology students for the concept of translation in protein synthesis. In order to do so, interviews were conducted to capture the information given by individual student regarding their analogies and how they generated the analogies. This is to obtain an in-depth understanding of the analogical reasoning of the students which could not be determined directly from questionnaires nor the tasks performed. This paper will discuss the planning and implementing of qualitative interviewing throughout the data collecting process to gather the students' thoughts while they had generated the analogies.

Introduction

My first few years teaching Biology at the university level was smooth sailing as the students had a sound and solid basic knowledge at the secondary level. However, stress and anxiety caught me when the university was asked by the Ministry of Education to upscale the knowledge and skills of in-service primary school teachers in order to award them a Bachelor's degree. These teachers have no subject matter specialization whatsoever and have taught for more than 15 years. Teaching molecular biology to this first cohort of in-service teachers was a nightmare as they perform badly at almost every test and examination given. I just feel that there's more to just getting their test scores and reporting their grades every semester. My notion tells me that something is missing, to know and understand 'why they keep on failing?' Was it my teaching or their poor basic knowledge of biology? My substantive interest at this point was 'why' this happens and 'how' am I going to overcome it? I now noticed that numerical data is not sufficient and cannot answer my questions. I have to supplement it with narratives or a case history to capture additional nuances. I begin to believe that qualitative data is more suited to provide me with answers to the questions asked and perhaps to other questions which I'm interested in. In my doctoral thesis, I was interested in how I could use analogies to teach my in-service teachers abstract biology concepts and to gauge their analogical reasoning of the analogies produced.

This paper draws from the research methods and procedures that I employed for my doctoral thesis, "Science Students' Self-Generated Analogical Reasoning of the Concept of Translation in Protein Synthesis". The study attempts to explore the analogical reasoning of biology students from a matriculation college in the vicinity of Kuala Lumpur. It attempts to do so by interviewing the students' analogies of the concept of translation and how they had generated them. I will briefly review the qualitative interviewing technique that I undertake as part of the research methodology employed and putting emphasis on the planning and implementation of the widely used individual face-to-face in-depth interview. This will

include a discussion of the process of conducting in-depth interviews and relevant ethical issues to be considered.

Gentner (1989) defined analogy as the mapping of a system of relations from the 'base' to the 'target' while Earnest & Treagust (2006) defined analogy as a process of identifying similarities between two concepts. Based on these two definitions, I defined analogy as a concrete and visualizable representation via pictures, drawings or descriptive words of the matches and mismatches between the 'source' and 'target' concepts. The 'source' concept is one that the student is familiar with from previous experience. It is a concrete and visualizable concept obtained from the surroundings or from situations in the environment. The 'source' concept also represents the analogy and is used interchangeably. An example of a 'source' concept is the 'camera' as in the 'camera' analogy for the 'human eye' or the 'train' as in the 'train' analogy of translation. A 'source' concept consists of various features that is normally compared and contrasted with the sub-concepts of a 'target' concept. Analogical reasoning on the other hand can be defined as the ability to transfer relational information from the 'source' or 'base' domain to the 'target' (Vosniadou, 1989). My study adapts certain aspects of the definition of analogical reasoning by Vosniadou (1989) in that, it refers to the thinking processes occurring in the human mind as one tries to generate analogies of an abstract concept learnt.

Why interview?

Interviewing was one of the techniques used in my study to gather information besides observation. Other than the interview protocol, an analogy task, a test and students' journals was used to collect data. Interviewing or the careful asking of relevant questions can be considered as an important way for a researcher to check the accuracy of – to verify or refute – the impressions he or she has gained through observation (Fraenkel & Wallen, 2006). In interviewing, there is direct verbal interaction between the interviewer and the respondent compared to self-report tests, inventories and questionnaires (McMillan, 2004). According to Fraenkel & Wallen (2006), structured and semi-structured interviews are verbal questionnaires designed to elicit specific answers from the respondents. They are also used to obtain information that can later be compared and contrasted. In the case of my study, I used open ended structured interviews to capture the information given by individual students regarding their analogies and how they generated the analogies. This was to obtain an in-depth understanding of the analogical reasoning of the students which could not be determined directly from the Translation Analogy Task (TAT), observation or the students' journal. For example, open ended questions like:

1. When asked to generate the analogy for translation, what first came to your mind?
2. What makes you think as such?

Answers to these questions could not be observed directly, via their analogies generated neither the journals written. As such it should be coming directly from the respondents' word of mouth and it is via face-to-face interviews that we are able to obtain such information. It is from the information obtained from each individual respondent can the students' analogical reasoning be compared and contrasted among the different achievement groups.

Importance of interview

Interviews are important in any conceptualization study that has something to do with the workings of the mind. This is because students' ideas that could only be expressed in language would be further exposed during the interviews. According to Fraenkel & Wallen (2006), the purpose of interviewing people is to find out what is on their mind – what they think or how they feel about something. This statement was remarked as:

“We interview people to find out from them those things we cannot directly observe. The issue is not whether observational data is more desirable, valid, or meaningful than self-report data. The fact of the matter is that we cannot observe everything. We cannot observe feelings, thoughts, and intentions. We cannot observe behaviors that took place at some previous point in time. We cannot observe situations that preclude the presence of an observer. We cannot observe how people have organized the world and the meanings they attach to what goes on in the world. We have to ask people questions about those things”.

(Patton, 2014, pp. 291)

In whatever situations it may be, the interview is used to gather descriptive data in the respondents' own words so that the researcher can develop insights on how respondents interpret some piece of the world (Bogdan & Biklen, 2003).

The purpose of interviewing was to allow the researcher to gather the students' thoughts while they had generated their analogies. The interviews also helped to support and triangulate the data obtained from the TAT, observation and the students' journal writings. This allows the sharing of a rich description of the analogical reasoning processes so as to provide meaning and perception to better understand and generate hypotheses as designed in qualitative interviewing. The interview questions were structured so that it would not drift from the main objective of probing students' analogical reasoning of the concept of translation. In addition to this, the interview technique is more flexible and can give students the freedom to think and answer without any limitation as the students have the opportunity to question the interviewer if there were questions which they do not understand. This is in view with McMillan's (2004) notion whereby more accurate responses are obtained as the interviewer clarifies questions that the respondent may have and follows up leads (probing). Finally, it is believed that the interview technique is the best technique to attract the students interest to answer honestly and in-depth. Again it is agreeable with McMillan (2004) in that an interview enhances the respondent's motivation and allowed information to be obtained that might not otherwise have been offered, once a good and proper rapport is established between the interviewer and interviewee. Other advantages of using the interview technique includes (i) greater depth and richness of information, (ii) can observe non-verbal responses and behaviors, and (iii) reduces the number of 'no answers' or neutral responses since the interviewer can press for more complete answers when necessary. It has been observed that face-to-face interviewing usually achieve higher return rates as compared to interviewing using questionnaires and often as many as 90 or 95% of the subjects will agree to be interviewed (McMillan, 2004).

Planning and Preparation before Interview

Before proceeding with the data collection process that is conducting the interview proper, the following phases were planned, (i) gaining access to the site and establishing a rapport,

(ii) getting acquainted, (iii) familiarizing students with analogies and practicing generating analogies and (iv) the actual study - conducting the interviews

(i) Gaining access to the site and establishing a rapport

I made frequent visits to the college to discuss the research with the college academic staff. One of the most important and essential component of qualitative interviewing as described in McMillan (2004) is the process of establishing rapport. As such, it is necessary for me to rapidly develop a positive relationship especially during in-depth interviews. Rapport involves trust and a respect for the interviewee and the information he or she shares. It is also the means of establishing a safe and comfortable environment for sharing the interviewee's personal experiences and attitudes as they actually occurred. It is through the connection of many truths that interview research contributes to our knowledge of the meaning of the human experience.

Rapport with the college principal, science coordinator and academic staff was initiated by conducting several preliminary and pilot studies with them before the actual study. For example the science coordinator, who specializes in biology assisted with the document verification. She was also one of the coders for the reliability check of the categorization of the analogies through the TAT and the students' verbatim interview responses. An earlier batch of science students from the same matriculation college was involved in the pilot tests for the instruments (Translation Test, TAT and interview). The following steps were taken to construct the structured interview questions.

- (i) The original interview questions were first discussed with the group of experts and changes made where required.
- (ii) Then, the questions were pilot tested with a first group of matriculation science students from another college and again revised.
- (iii) The revised interview questions were showed to the experts for the second time to be discussed and validated.
- (iv) It was then, pilot tested again twice, firstly, with a second group of matriculation science students from another college and then, with a different student sample from the same matriculation college.
- (v) The final interview questions (after revision and correction) were agreed upon by the experts (a biology coordinator and teacher from the matriculation college and three senior biology lecturers from one of the local university) before being used in the actual study. The initial and final corrected interview questions are shown in Table 1.

The why and how questions in the interviews were used to probe the students so as to capture more information pertaining to the analogical reasoning occurring in the minds of the students. These qualitative data were to provide the 'depth' and 'richness' of the students' self-generated analogical reasoning process for the concept of translation.

(ii) Getting acquainted

Rapport with the administrative staff, academic staff and the students is a prime requirement in qualitative research. I was introduced to the students during their orientation. Following this and prior to the data collection, I conducted various activities with the students such as

Table 1. The initial and final corrected interview questions

Interview questions before correction	Interview questions after correction
1. When I first asked you to generate an analogy of the concept of translation, what first came to your mind?	1. You have generated an analogy of the concept of translation. Can you tell me what was on your mind (your thinking) when I first asked you to generate this analogy?
	2. Why did you think as such?
2. Why did you choose this analogy?	3. Why did you choose this analogy?
3. Explain how you obtain this analogy?	4. Can you explain to me, step by step how you arrive at this analogy?
4. Describe your analogy with the aid of a diagram?	5. Tell me what are the sub-concepts in translation that you match?
5. Explain how you determine the similarities between the 'source' and 'target'?	6. Why do you match them?
	7. How do you match them?
6. Describe what you think and do if you encounter with mismatches between the 'source' and 'target' concepts?	8. As you proceed with the matching, what happens to the other (the rest of the) sub-concepts of translation? Why?
7. How are you going to react to the mismatches? Why?	9. How are you going to deal with this?

assisting the teachers to conduct biology revision classes, tutorial classes and tests. All the activities were conducted during their lecture hours, tutorial hours or special allocated sessions for my study.

After being with the students and getting to know them for several sessions, I finally explained the purpose of the research and asked for their cooperation. Since the topic on protein synthesis was taught during the second semester, the students had some time to know and practice generating analogies individually and in groups. I would interact with the students at every meeting which was allocated for me during the first semester. During the 11 weeks of lectures in the first semester, I had four full sessions of two hours each to introduce, practice and discuss analogies. These practice sessions were important and necessary because analogies and analogy generation are still new and at an early stage in the science curriculum of the Matriculation college. As such, it was assumed that majority of the students have little or no idea whatsoever of analogies.

(iii) Familiarizing Students with the Analogies

The subjects were introduced to the meaning of the term analogy and they practise to generate analogies of a different science concept, first in small groups of 4 to 5 people and then individually.

(iv) Actual Study – Conducting the interviews

The actual study was conducted in three sessions. The first session was the observations of the lectures, the second session was the revising session with the students and the third session was administrating the TAT and conducting the interviews. In this paper, I will only focus on conducting the interview.

Immediately after administering the TAT, I conducted a one-to-one interview with the students based on the interview schedule which had been drawn up. I should say that even though an interview schedule has been drawn up, it is still fluid in the sense that it must be flexible to allow for unforeseen circumstances that is bound to happen. These are some of the setbacks of interviewing which will be discussed in another section of this paper. Next, the ethical dimension of the interview needs to be borne in mind, ensuring, for example, informed consent, guarantees of confidentiality, beneficence and non- maleficence (i.e. the interview may be to the advantage of the respondent and will not harm him/her). The issue of ethics also need to be taken into account for example, informing the interviewee that the session will be audio and video-taped.

Before the interview proper, I tried to acquaint with the interviewee by talking about mundane issues such as family background, former student life, ambition, hobbies, likes and dislikes and such. According to Bogdan & Biklen (2003), the purpose of this initial chit-chat is to develop accord that is to search for a common ground, a topic that is in common and a place to begin building a relationship. This so call ice-breaking session may take from a split of seconds to a few minutes depending on how well the interviewer knows the interviewee. Once the interviewee felt relaxed and acquainted, I begin the interview by informing the purpose of my study and make assurance that what is said in the interview will be treated confidentially. This assurance is further supported by giving them a consent form. Once the interviewee have read and agreed to sign the consent form, I started the interview guided by the corrected interview questions. The students' analogies were used to assist in the interview whenever required. Empty sheets of paper and pen were also provided for the students to write, scribble and draw whenever they wanted. The interview sessions was video taped and so it gave the researcher the opportunity to observe the interview sessions as well.

Interview Site

The college authorities were nice enough to allocate a special room, a room supposed to be neutral, to carry out the interviews. At times I would change the place of interview for instance, at the science laboratory, in the staff room or in an empty classroom to kill the environmental monotony and the so-call too rigid and confined place. I feel that a bigger, more spacious and less secluded place would be better since it can create a more free, friendly and conducive environment to enable the interviewee to feel free to speak their minds. Irrespective of where the interview was carried out, it was assisted by an audio and video capture. A specific consent form for tape-recording was signed prior to the interview.

Strengths and weaknesses experienced during the interviews

As mentioned earlier, the purpose of the one to one interview was to probe in-depth responses and 'richer' data pertaining to the analogical reasoning of the students and the generation of analogies. Examples of individual interviews are shown below.

R: What was your thinking when asked to generate analogies of translation?

L: I feel happy.

A: Feel very happy because given the opportunity to create my own analogy.

H: Afraid but at the same time challenging.

(Excerpt)

R: When I ask you to generate an analogy for 'translation', what first came to your mind?

*L: Initially, I imagine the **process** of 'translation' whereby the **move** on the 'mRNA' strand.*

*A: I see that 'translation' has many stages. So to get an analogy, it must be related to some kind of **stages**.*

*H: Sometimes the documentary shows how to mine ore. However, mining ore is interesting, mine the ore and later the ore will be **processed**....like we want to synthesize protein.*

(Excerpts)

The several interview already conducted with the students revealed that they noticed both the matches and mismatches in their analogy. This was implied in their verbatim responses by comparing and contrasting between features of the 'source' and 'target' concepts.

(Researcher's audit trail)

R: Why did you think of this analogy?

*L: Ah...as for me, I **want** to do something which is difficult that uses my own idea.*

*A: I feel that there is more matches, so easier for me **to remember**.*

(Excerpts)

R: Why did you choose this analogy?

*A: As for me, it is **very interesting**, the process of producing newspaper*

*H: When I was in Form 3, I **like** the subject Geography so I learn the mining process.*

(Excerpts)

*Students will first draw up a list the sub-concepts of translation and then state the **functions** in another column. Following this is another column of features of the 'source' concept, then they will list the similarities between the two based on the **functions** identified earlier.*

(Researcher's audit trail)

R: Why did you choose a train as your analogy?

L: The mRNA is like the passenger, the ribosome...its function is to move from one codon to another, so it can be related to the journey of a train

A: Because I see the Japanese restaurant, unlike other restaurants, the place where they serve the food is moving...like a train

(Excerpts)

H: To me, the bus seems more suitable because it functions like translation, stop, pick up passengers, move and then stop again, some passengers will go down and some will come up the bus. This is like tRNA carrying the amino acid, it will attach to the ribosome, leave the amino acid, go down.

(Student's journal)

The data from the interviews help makes transparent the cognitive processes occurring in the minds of the students during analogy generation and strategies taken in response to the mismatches. Good interviews can get a true insight of what's going on in the interviewee's mind and this can produce rich data filled with words that reveal the respondents' perspectives. Also through interview, we can as well know via observation whether a person is telling the truth via their body gestures, facial expressions etc. The audiotapes and videotapes used in the interview may be replaced several times for continued study and analysis. Experts and interested others can also hear and/see what the researcher observed and offer their insights accordingly. A permanent record of certain behaviours can be obtained for comparison with later or different samples.

These are some of the strengths of conducting an interview technique. Oppenheim (2005) suggests that interviews have a higher response rate compared to other means of data collection such as the questionnaire because respondents become more involved and, hence, motivated. Interviews also enable more to be said by the respondents regarding the research than is usually mentioned in a covering letter to a questionnaire. Different types of interviews have different characteristics and thus, have their own strengths and weaknesses as summarized by Patton (2014).

- i. Despite the strengths of interviewing, there are also certain weaknesses that need to be accounted for. For example, there is a possibility of the interviewer being bias and this may influence what they hear or record. Another weakness is the 'halo effect' which can also occur with interviewers. This occurs when an interviewer allows an initial impression about one aspect of a person to influence the information obtained of another aspect. Some of the problems which I encountered during the interviewing sessions was being impatience. I want quick answers from the interviewee without giving them ample time to think and answer my probes. Occasionally, I get drifted away as I probe the interviewee and by the stories they told. Being too rigid by following closely to the interview questions asked, may not give me any information. I also noticed that I forget the information obtained if not transcribed immediately. Transcribing interviews is also time consuming, thus I employ a transcriber. Another of my weaknesses is to lead the interviewee to the answer desired (feed the respondents with responses or made them feel uncomfortable with their own thoughts) and to put words into the respondent's mouth. I also find it difficult to ask questions and jot notes at the same time. At times I unintentionally use questions that allow for a 'yes' and 'no' answer and also interrupt the subjects and change the direction of the conversation.

Addressing the problems encountered

I managed to overcome many of the above mentioned problems (except iv, v and viii) as I practice interviewing in my pilot study. This was possible because as there were several stages of pilot study prior to the actual study to validate the research instruments. One tends to get acclimatized to the situation as one repeats the action. Similarly, the first few initial interviews

got me drifted away from the focus of the research. Once I have acquired the technique of probing, I managed to stay in focus. The same goes with being rigid in the interview. After several sessions of interview, I did not have to refer to the interview protocol and the interviews went smoothly gathering more information. I also learned through the mistake of conducting many interviews per week as I could not finish transcribing before the next interview. So I decided to employ a transcriber to assist with work and I learnt to tabulate my interview slots accordingly. I also accumulated the week's transcript before analyzing them and when I analyzed them, I found that there were many similar and repeated flaws and loop holes which were not accounted for. From there plus further reading and consultation with my supervisor led me to realize my mistake of not fully understood the constant comparative method of analysis. The idea of audio and video recording of my interview sessions was thought of when I realized that I was slow in jotting down the interviewee's response and to capture their behavior.

Another way to overcome the above problems as suggested by Creswell (2008) is to draw up a checklist for the general steps in interviewing before conducting the interview. Some of the important points to be considered in the checklist are shown in Table 2.

Table 2. Interview Checklist

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1. Identify the participants.
 2. Determine the type of interview to conduct.
 3. Ensure the setting for the interview is comfortable and quiet.
 4. Prepare and test the equipments for interviewing (e.g audiotapes, video tapes, etc).
 5. Obtain consent to interview from participants.
 6. Listen more and talk less during the interview.
 7. Probe to clarify and elaborate answers during the interview.
 8. Avoid leading questions (ask open-ended questions).
 9. Keep participants focused.
 10. Withhold judgments and refrain from debating with participants about their views.
 11. Be courteous and thank the participant after the interview.
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Trustworthiness of the data

I also kept an audit trail of all the daily activities, discussion with peers and advisors and flow of ideas on a day to day basis. It was somewhat like a personal journal whereby new ideas could be built up as the analysis proceeded with more and more data coming in. For example, at the end of one student's interview session, my audit trail report confirmed the impact of the words 'move' or 'movement' used by the students as shown below.

'After interviewing 8 students throughout this week, it was observed that 6 out of 8 of them kept on mentioning about 'movement of the ribosome'. Based on this phrase, they ended up with a 'source' concept that denoted some kind of movement such as a 'train', a 'car' and such'.

(Audit trail report)

The audit trail reaffirm that almost all the students from the three different achievement groups would mention the words 'move' or 'movement' from time to time throughout the interview.

As stated by Merriam (2015), it is important for researchers to write their reflections immediately after an interview. This was because the researcher's reflection might take into consideration the insights from the interview description either verbal or nonverbal of the interviewee's behaviour, parenthetical thoughts of the researcher and such (Merriam, 2015).

Similarly, discussions with experts, co-advisor and peers and their comments in the analysis of qualitative data, helped me to modify and collapse the categories and sub-categories as indicated in my audit trail below.

A pattern is starting to emerge slowly. All the three different achievement groups will focus on key words in translation such as a 'process', 'movement' etc. They seem to put emphasize on the biology module by looking at the diagrams. The diagrams in the biology module have a strong influence on them. Adapt directly from the biology module for example the 'train' analogy. The low and average achievement groups based their analogies on their interest, what he/she wants, intend to have.

(Audit trail report)

The audit trail is among one technique to meet the evaluative criteria posited by Lincoln and Guba (1985) on the trustworthiness of a research study. This involves establishing credibility, transferability, dependability and confirmability which is important to evaluate its worth. In this study, the audit trail and triangulation establishes confirmability, the thick description establishes transferability and member checking establishes credibility.

Conclusion

This article briefly discuss the planning and implementation of a common qualitative interview method which is individual face-to-face in-depth interview widely used in qualitative research to date. Qualitative interviewing seeks to foster learning about individual experiences and perspectives on a given set of issues, in this case, gauging students analogical reasoning of an abstract biology concept. The methods for conducting in-depth interviews and the relevant ethical issues to be considered with particular regard to the rights and protection of the participants was also mentioned.

Based on my personal experience, I should say that before embarking on a particular data collection technique in qualitative research, it is best to plan first to ensure less obstacles being encountered during the process and for best results. Thus it is advisable and appropriate to first identify and define the research problem and research questions. One need to always think through whether qualitative interviews are appropriate to the research problem and questions asked. This is because there are many different forms of qualitative interviewing as well as other types of qualitative research methods that can be used for different problems. For instance, if you are collecting facts or perceptions, would a questionnaire make more sense?

While all interviews are used to get to know the interviewee better, the purpose of knowing varies according to the research question and the disciplinary perspective of the researcher. In this study, I used open ended structured interviews as a technique in qualitative interviewing to capture the information given by individual students regarding their analogies and how they generated the analogies. Another important criteria to consider when planning and conducting qualitative interviewing is to establish rapport so as to gain access of the interviewee and the interview site. This is an essential component of interview as it involves

trust and respect for the interviewee and the information to be shared. It is also the means of establishing a safe and comfortable environment for sharing the interviewee's personal experiences and attitudes as they actually occurred. It is through the connection of many truths that interview research contributes to our knowledge of the meaning of the human experience. In line with this are the ethical issues that are equivalently important to be considered and taken into account seriously. The basic ethical issues is to obtain consent from the interviewee in terms of their participation in the interview and the confidentiality of the findings before conducting the interview. One final important aspect to consider in qualitative interviewing is the art of conducting the interview which needs numerous practices to make it perfect. It is usual for a beginner in qualitative research to experience problems initially as I have experienced and mentioned earlier. However, with consistent practice over time, many of the obstacles and weaknesses can be overcome gradually.

It can be concluded that qualitative interviewing takes place when a researcher asks one or more participants general, open-ended questions and records their answers. What I have learned throughout my data collection technique is that qualitative interviewing provided a rich and in-depth information about the experiences of individuals which will contribute to a body of knowledge that is conceptual and theoretical and is based on the meanings that life experiences hold for the interviewees.

References

- Bogdan, R. C., & Biklen, S. K. (2003). *Qualitative Research for Education. An Introduction to Theory and Methods*, 4th edition. Allyn and Bacon.
- Creswell, J.W. (2008). *Educational Research. Planning, Conducting and Evaluating Quantitative and Qualitative Research*. 3rd edition. Pearson Education, Inc.
- Earnest, J., and D. F. Earnest & Treagust (2006). Setting the Scene: Providing the Framework and Context. In *Education Reform in Societies in Transition*, ed. Jaya Earnest and David Earnest & Treagust (2006), 1-12. Rotterdam, The Netherlands: Sense Publishers.
- Fraenkel, J. R., & Wallen, N. E. (2006). *How to design and evaluate research in education*, 6th edition. McGraw-Hill, Inc.
- Gentner, D. (1989). The mechanisms of analogical learning. In S. Vosniadou & A. Ortony (Eds.). *Similarity and analogical reasoning*. p. 199-241. Cambridge MA: Cambridge University Press.
- Glaser, B. G. & Strauss, A. L. (2012). *The Discovery of Grounded Theory: Strategies for Qualitative Research*. 7th edition. Transaction Publisher Rutgers-The State University, New Jersey.
- Lincoln, Y.S. & Guba, E.G. (1985). *Naturalistic Inquiry*. Newbury Park, CA: Sage Publications.
- Maria Salih (2008). A Proposed Model of Self-generated Analogical Reasoning for the Concept of Translation in Protein Synthesis. *Journal of Science and Mathematics Education in Southeast Asia*. Vol. 31(2), p 164-177.
- McMillan, J. H. (2004). *Educational Research Fundamentals for the Consumer*, 6th edition. Pearson Education, Inc.
- Merriam, S. B. & Tisdell, E. J. (2015). *Qualitative Research: A Guide to Design and Implementation*. John Wiley & Sons, Inc. San Francisco, CA.

Oppenheim, A. N. (2000). *Questionnaire Design, Interviewing and Attitude Measurement*. London: Pinter Publishers Ltd.

Patton, M. Q. (2014). *Qualitative Research and Evaluation Methods: Integrating Theory and Practice*. Newbury Park, CA: Sage.

Strauss, and Corbin (1990). *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory*. 2nd edition. Kluwer Academic Publishers-Human Sciences Press.

Vosniadou, S. (1989). Analogical reasoning as a mechanism in knowledge acquisition: A developmental perspective. In S. Vosniadou & A. Ortony (Eds.). *Similarity and analogical reasoning*. Cambridge MA: Cambridge University Press.



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