Divergent and Convergent Thinking Skill

1. What is Divergent and Convergent Thinking Skill
Divergent and convergent thinking skills are the important cognitive processes involved in solving problems (Guilford 1957). Divergent thinking seeks understanding the problem from multiple perspectives and generating multiple solutions. While, convergent thinking is the process of evaluating and selecting the most optimal solution based on some criteria (Basadur 1990).

1.1 Importance of Divergent and Convergent Thinking Skill
The divergent and convergent thinking skills are important in the process of problem solving in all domains where the concepts learned can to be applied to solve real life open problems.

It is one of the important engineering design competencies needed to design a system, product, electronic circuit, network, etc., for a given real life open problem. In engineering design process, a designer has to follow a systematic problem solving process having phases- understand the problem, design a solution and implement. By incorporating divergent and convergent thinking in each phase, the outcome can lead to better or innovative solution.

1.2 Sub-Skills and its definitions
During problem solving, it is assumed that divergent thinking leads to original and innovative ideas. The literature on creative thinking widely uses following sub-skills to assess divergent thinking (Liu 2004, Cooperrider 2008, Runco 2012, Basadur 1990)-

1. Fluency: the ability to generate many solutions or ideas.
2. Flexibility: the ability to generate varied ideas.
3. Originality: the ability to generate unusual or novel responses.
4. Elaboration: the ability to elaborate an idea with technical details and concepts.

The term convergent thinking was coined by Guilford as an opposite term to divergent thinking. It involves evaluating and selecting the most optimal solution. The sub-skills associated with convergent thinking are (Madhuri 2015)-

1. Selection of accurate solution based on constraints or principles.
2. Pros & cons analysis.
2. Broad Learning Objectives for Divergent and Convergent Thinking Skill

The learning objectives should be such that it develops following divergent and convergent thinking skills while solving the open-problem

1. Students will be able to identify the entities and stakeholders involved in a given problem (Divergent thinking).

2. Students will be able to identify the attributes associated with each entity and stakeholder (Divergent thinking).

3. Students will be able to identify the interactions or relationships among entities and stakeholders (Divergent thinking).

4. Student will be able to identify functions to be achieved based on the requirement or goal of a problem (Convergent thinking).

5. Student will be able to identify the components and interconnections needed to solve the problem (Convergent thinking).

6. Student will be able to generate multiple ideas or solutions (Divergent thinking).

7. Student will be able to evaluate all the solutions based on the constraints or assumptions (Convergent thinking).

8. Students will be able to select and justify the most suitable solution based on the evaluation (Convergent thinking).

3. Contextualizing the Divergent and Convergent thinking skill for a domain- Data Structures

The application of divergent and convergent thinking skills in Data Structures is illustrated in this section. The broad learning objectives given in section 1.3 are contextualized and written as specific learning objectives for Data Structures course. The specific learning objectives are explained using a following open design problem in data structures- “A bank with thousands of customer records is interested in building an online service for its customers. The services to be offered to customer are- to be able to check account details online, to do online transaction, and transfer money to other accounts. Design an efficient solution using appropriate data structure and operations.”

Learning Objectives:

1. **Students will be able to identify the entities and stakeholders involved in a given problem.**

   For example, in the above bank problem, the entities are account-books, transaction-register, cash counters, and stakeholders are employees and customers.
2 Students will be able to identify the attributes associated with each entity and stakeholder.

Specific LO in data structure- Student will be able to identify attributes like data items and operations associated with each entity and stakeholder.

For example, in the above bank problem, the entity-

- Account-books will have data items- account number, customer name, balance.
  operations are- search (account number), update_balance(account number), insert(account number), delete(account number).

- Customer will have data items- account_number, amount, date.
  operations- withdraw(), deposit(), display().

- Employee will have data items- employee_id, data_of_joining.
  operations are- create_new_account(), search (account number), update_balance(account number), insert(account number), delete(account number).

3 Students will be able to identify the interactions or relationships among entities and stakeholders.

Specific LO in data structure - Student will be able to identify the relationship between operations and data items of an entity.

In above problem the operation withdraws or deposit is related to balance in account books.

4 Student will be able to identify goals or functions to be achieved based on the requirement.

For example in the above problem, the goal is to design an online banking system and functions are to allow customers to check account details online, to do online transaction, and transfer money to other account.

5 Student will be able to select the entities, stakeholders, components and interconnections based on the requirement.

Specific LO in data structure - Student will be able to select the entities, stakeholders and data and operations needed to solve based on the identified functions.

For example, in the above problem, the entities selected are

- account books will have data items- account number, customer name, balance.
  operations are- search (account number), update_balance(account number).

- customer will have data items- account_number, amount, date.
operations- withdraw(), deposit(), display().

- Employee will have data items- employee_id, data_of_joining.

operations are- search (account number), update_balance(account number)

6 Student will be able to generate multiple ideas or solutions.

Specific LO in data structure - Student will be able to generate multiple solutions using multiple data structures to represent data and solve the identified operation.

For example, for the above problem, multiple solutions using different data structures are:

1. Use an array data structure to store the records in the order the customer account was created and use linear search algorithm to retrieve the customer account details when requested.

2. Use hash table to store the customer records using customer id as the input to hash function to get the address of customer record.

3. Use balanced binary search tree to store customer records and use binary search algorithm to retrieve customer record.

7. Student will be able to evaluate all the solutions based on the constraints or assumptions identified.

Specific LO in data structure-

Students will be able to identify constraints on parameters like memory requirement and execution time to evaluate generated solutions.

OR

Student will be able to do pros and cons analysis of all the solutions based on the constraints or assumptions identified.

For example, for above problem,

a) The array solution will take at the worst case O(n) time to search and generate response.

b) The hash table solution in best case takes O(1) time.

c) The binary search tree solution takes O(log n) time in all cases to search a customer record.

8. Students will be able to select and justify the most suitable solutions based on the evaluation or analysis.

The efficient solution is hash table as the time of execution to search is less than array and binary search tree.
4. Guidelines for choosing a topic to teach divergent and convergent thinking

The following guidelines are recommended to choose a topic:

1. The topic in which open problems can be posed and can be solved in multiple ways and has multiple solutions. The problem should not have a very obvious solution, e.g. if problem asked in Data Structures course is “Which data structure is suitable to reverse a string?”, the solution stack is a very obvious solution.

OR

2. The topic having concepts which can be applied in multiple disciplines, for example the data structure concepts can be applied to solve problems in multiple disciplines like banks, inventory management, library, etc.

3. Guidelines for writing specific learning objectives for the chosen topic

The following guidelines are recommended to write learning objectives for developing divergent and convergent thinking in the chosen topic:

1. Identify or generate an open problem for the chosen topic.

2. Solve the open problem by applying the broad learning objectives.

3. Identify the specific terms that can be used to replace the broad terms in learning objectives. For example in learning objective 2- “Students will be able to identify the attributes associated with each entity and stakeholder”, the term attributes can be replaced by specific terms or concepts identified during solving the problem.

References


