

# Achieving Effective Micro-Lecturing using Micro-Tutorials and Micro-Learning-Patterns

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## Abstract

The traditional micro-lecturing process consists of a micro-lecture followed by an assignment. The complete micro-lecturing process aims to impart understanding skills to students. According to Bloom's taxonomy, the prime objective of a lecturing process is to nurture students' memorization, understanding and application skills. However, due to short lecturing time, micro-lectures often fail to impart application and memorization skills to students. Can we design a micro-lecturing process capable of imparting all three skills to students? This research uses micro-tutorials and micro-learning patterns (MLP) to address this problem. This research explains how the traditional micro-lecturing process can be modified using micro-tutorials and MLP's to enhance students' all three skills simultaneously.

A micro-lecture aims to explain a topic. On the other hand, MLP's provide a systematic way to (a) understand a topic, (b) memorize essential elements associated with the topic and (c) allow learners to apply the gathered knowledge to solve associated problems. These MLP's are implemented using an ordered triplet consisting of micro-lectures, micro-tutorials, and assignments. In this ordered triplet, micro-tutorials are sandwiched between micro-lectures and assignments. So, this ordered triplet can be considered as the modified version of the traditional micro-lecturing process. This modified micro-lecturing process nurtures students' all three skills simultaneously. This happens because, in the modified micro-lecturing process, a micro-lecture explains a topic, nourishing students' understanding skills. This micro-lecture also provides pointers concerning different application areas associated with the topic. Micro-Tutorials uses these pointers to enhance students' application and memorization skills. At the same time, assignments help students to practice and apply their skills to solve different sets of problems.

To prove the validity of our proposed approach, we floated a twenty-day-long 'C' programming course for 62 registered students. We used the modified micro-lecturing process to teach registered students and observed excellent results. For example, we observed a hike of more than 25% in students' problem-solving, application and programming skills. We strongly believe that this research help educators to design pedagogically effective micro-lectures and micro-lecturing systems.

**Keywords:** Micro-Lectures, Micro-Tutorials, Bloom's Taxonomy, Assignments, Micro-Learning Patterns

## 1. Introduction

Micro-Lectures (MIL) are gaining popularity because they are short 1-3 minutes lectures, densely populated with knowledge, and focus only on the core content. During the COVID-19 pandemic, demand for micro-lectures increased rapidly [16]. Due to short lecturing time, micro-lectures often fail to satisfy the core learning objectives described in Bloom's taxonomy. Hence, designing micro-lectures is not an easy task. Micro-lectures are suitable for imparting concept understanding skills to students. However, they are generally not suitable for students' memorization and application skills. Can we impart memorization, understanding and application skills to students using micro-lectures? What is the process of designing a micro-lecture that imparts all three skills to students? This research addresses these problems using micro-tutorials (MTUT) and micro-learning patterns. We discovered many patterns under the MLP category, like micro-prompt, micro-interrogation, and others [14]. However, we used the MLP pattern named application & memorization pointer pattern for this research. Section 5.3 presents the complete details of this pattern.

The terminology which we used throughout this research is presented in section 2. It contains important keywords along with their meaning, followed by two ways using which we classify students. Section 3 presents related work. Then this research presents the traditional micro-lecturing process and five critical issues associated with it (see section 4). The research explains how issues 1-4 are addressed in other papers and how we will address issue 5 in this paper. Section 5 presents the methodology used and the results. This section explains in detail how MIL components are architected, MTUTs, MLP pattern (application & memorization pointer pattern), and how these elements are used to modify the traditional micro-lecturing process. So the MILs generated using the modified process enhance students all three skills discussed above simultaneously. To prove the validity of our proposed modified micro-lecturing process, we floated a twenty-day long course on C programming. Throughout this course, we taught students using the modified micro-lecturing process. We observed a wonderful performance hike in students' performances concerning several parameters related to the aforementioned skills. We also collected students' feedback concerning this method and got positive acknowledgements. Section 5 presents all results and feedback analysis. We conclude this paper by highlighting key findings in section 6. We feel that this research opens a new dimension in the field of micro-lecturing.

## **2. Terminology Used**

These topics are composed of several concepts and sub-concepts. These concepts and sub-concepts can be grouped to form knowledge point (KP) structures. These KPs help to design micro-lectures. KPs are classified under three categories: (a) Independent KP, (b) Dependent KP and (c) Chained-Independent KP.

KPs that do not have any pre-requisite KP associated with them are called independent KPs. On the other hand, KPs that have pre-requisite KPs associated with them are known as dependent KPs. Moreover, chained-independent KPs associate at least two independent sets of pre-requisite KPs.

The KP classification given above helps to form KP-Hierarchy. This hierarchy arranges the classified knowledge points in the form of a tree. This tree helps to find (a) the order in which KPs are explained to the students, (b) the relation between connected KPs and (c) other parameters concerning lecture design like lecturing time, lecture complexity, content depth, content creation time and others.

This research classifies students in two ways (a) using their class performance and (b) using their learning styles. In (a) students are classified under three groups based on their class performance, namely High-Performance Group (HPG), Moderate-Performance Group (MPG) and Low-Performance Group (LPG). In (b) students are classified based on their learning styles or learning abilities. For example, students who learn by memorization (LBM) can be grouped as memory-centric students. Similarly, students who learn by doing (LBD) or investigation (LBINV) are grouped as understanding-centric students and so on.

## **3. Related Work**

Bloom's taxonomy defines learning objectives [1]. At the same time, the work done by Bandura explains the social-cognitive theory [2]. Norman Webb gave the concept of knowledge point and depth of knowledge [3], and Hess talked about content complexity rigour in his work [4]. These researches provide the essential foundation for research presented in this paper. Researchers also produced beautiful work on lecturing styles [5] and teaching variants [6]. These researches helped us better understand the teaching styles adopted by teachers and learning styles adopted by students. Several researchers talked about quality attributes associated with the lecture [10]. We used their research closely associated with the Delphi study to derive quality attributes concerning teaching a course on 'C' programming language. The importance of homework assignments [7-8] plays a vital role in designing lectures. Their importance amplifies while designing micro-lectures. Researchers from computer science presented their work on software patterns [11]. This research uses their work to craft learning patterns for students.

## **4. Understanding Traditional Micro-Learning Process and Associated Issues**

A micro-lecture (MIL) aims to explain a topic. A topic is composed of knowledge points (see Figure 1, step 0). Before designing a micro-lecture, the lecture designer must identify all KPs associated with the lecture. These KPs are then arranged in the form of a hierarchy using the KP classification scheme discussed in section 2. This hierarchy or tree is known as KP-Hierarchy (see Figure 1, step 1). The KP-Hierarchy is used to find the KP traversal order. This order arrange KPs present in KP-Hierarchy in sequence. This sequence helps find the order

in which these KPs are explained to the students (see Figure 1, step 2). MILs are designed using combinations of KPs arranged in sequence (see Figure 1, step 3). These MILs help students to understand the concepts. Each MIL is doped with an assignment. These assignments help students to practice the concepts explained in the MIL (see Figure 1, step 4). Figure 1 presents the traditional micro-lecturing process in detail.

Due to short lecturing time, micro-lectures suffer from several issues. Out of many issues associated with micro-lectures and the micro-lecturing process, we identified five major issues:

**Issue 1:** Overuse of assignments.

**Issue 2:** Unable to handle memorization skills.

**Issue 3:** Unable to handle application skills.

**Issue 4:** Unable to cater to students' need for error explanation and rectification throughout the learning process.

**Issue 5:** Unable to handle memorization, understanding and application skills simultaneously.

It is to be noted that we addressed issues 1-4 in our previous research. Issue 5 is the prime concern of this research. We proposed the micro-prompt strategy [12] and micro-interrogation strategy [15] to address issue 1. On the other hand, we proposed the micro-tutorial strategy to address issues 2-4 [13]. We also discovered several learning patterns that make the learning process easy for students [14]. This research uses the micro-tutorial strategy closely associated with the MLP pattern to address issue 5.

## 5. Methodology Used and Results

This section is composed of 5 sub-sections. Section 5.1 presents MIL components and the way they are architected. This section also discusses the importance of MIL components and associated quality attributes. Section 5.2 explains the concept of micro-tutorials. On the other hand, the application and memorization pointer pattern is presented in section 5.3. Section 5.4 shows how using elements discussed in the above sections; the traditional micro-lecturing process is modified so that MILs designed using the modified process handle memorization, understanding and application skills simultaneously. Finally, section 5.5 presents the modified process's validity and the results.

### 5.1 Architecting Micro-Lecture Components

A micro-lecture is composed of three components: **(a) introduction, (b) body and (c) conclusion**. These components are known as MIL components (see Figure 2 (a)). Due to short lecturing time, lecture designers generally do not design MIL components separately. However, MIL components must be designed separately and then integrated into a single unit to design effective micro-lectures because of the following reasons [9, 17-18]:

- A well-written lecture introduction leads to high motivation, learning excitement, curiosity, structured thinking, topic relevance, better understanding, and better applicability.
- An appropriately written lecture body makes a lecture simple, understandable, and easy to digest.
- A carefully written conclusion helps to recall the concepts addressed by the lecture quickly.

The quality of MIL components affects the overall quality attributes associated with the MIL. Carefully designed MIL components exhibit several properties. Some are as follows [10, 19-20]:

- (i) Make MIL clear, understandable, precise, and simple.
- (ii) Effectively relate all pre-requisite knowledge points.
- (iii) Provide pointers to the upcoming MILs and for application & memorization areas of the current MIL.
- (iv) Help learners to draw inferences.
- (v) Try to fulfil the learner's learning objective(s).

**Point (iii)** mentioned above is one of the most critical points concerning the quality of MIL because most MILs do not provide pointers to the upcoming MILs or application/memorization areas of the current MIL. However, for designing effective MILs, such pointers are mandatory. Moreover, when we use pointers that point to application or memorization or both areas of the current MIL, then the content associated with the area mentioned above must be presented in the respective micro-tutorial (see Figure 2 (b)).

We can use (s1) **interrogative**, (s2) **abstract**, (s3) **detailed** and (s4) **instructional styles** for designing MIL components, namely introduction and body. On the other hand, we can use a (s5) **simple summary** and (s6) **micro-visual tree styles** for designing the MIL conclusion. The styles (s1-s6) mentioned above are collectively called MIL designing styles. The micro-lectures designed using different MIL designing styles suits a particular type or group of students. These styles are briefly discussed below.

The MILs designed using an interrogative style are interrogative in nature. These MILs are filled with interrogative questions targeted to induce learning curiosity in students. These questions are a mix of known-unknown questions based on pre-requisite KPs and current KP. These MILs are suitable for application-centric students who generally follow LBD and LBINV approaches. On the other hand, MILs designed using abstract style are small, precise and densely loaded with content. They abstractly explain the topic. The content complexity rigor is generally high for abstract lectures. Such MILs are found suitable for students who belong to HPG. Students who belong to LPG and MPG need a detailed explanation of a topic. So, lectures designed using the detailed style are suitable for them. This style discusses in detail every KP associated with the topic under consideration. The content complexity rigor for these lectures is generally low. At the same time, the depth of knowledge is either high or moderate. These MILs are suitable for memory and application-centric students. Instructional style is used to design MILs for courses where instruction-based teaching is required, such as laboratory practicals. These MILs are found suitable for application-centric students.

A simple summary is one of the most simple and effective ways of designing conclusions. The conclusions designed using this approach are generalized and based on the LBM learning style. The simple summary conclusions are suitable for a wide range of students, including LPG, MPG and HPG students. The content complexity rigor is generally low or moderate in these conclusions. On the other hand, a micro-visual tree is the pictorial representation of a MIL. This tree pictorially concludes the MIL. A micro-visual tree is derived using the KP-Hierarchy associated with the given MIL. Every node represents a knowledge point in a micro-visual tree, and edges between the nodes represent the relationship among the connected knowledge points. Every node of a micro-visual tree contains the knowledge point name, associated description, and image (optional). Every edge of a micro-visual tree generally contains a description highlighting the relationship that exists between the connected nodes. The conclusions designed using this style have low content complexity rigor, and a high recall rate. All students (i.e., LPG, MPG and HPG students) have a strong affinity for conclusions designed using the micro-visual tree style.

**It is to be noted that pointers discussed in point (iii) are embedded in MIL's body and conclusion sections. Then they are handled by micro-tutorials (MTUT) which are embedded between MIL's and assignments (see Figure 2 (b)).**

## 5.2 Explaining Micro-Tutorials

Micro-tutorials (MTUT) are analogous to MILs. They are 1-3-minute-long tutorials closely associated with their respective MILs. MTUTs try to explain the memorization and application pointers embedded in a given MIL's body and conclusion sections. MTUTs help to enhance students' application and memorization skills. Apart from this, they help to highlight common mistakes (or errors) which students generally commit while solving a problem. MTUTs also provide remedies for these mistakes. MTUTs are generally placed between MILs and associated assignments.

## 5.3 The Application and Memorization Pointer Pattern

This section presents the application & memorization pointer pattern. This research uses this pattern to modify the traditional micro-lecturing process and design MILs from the modified process. We used a standard computer science pattern template that contains context, problem, forces, solution, examples and consequences to write this pattern. It is to be noted that this pattern is part of the micro-lecturing patterns, which contains patterns like micro-prompt, micro-interrogation and others, which are already discussed in other papers [12, 14].

Context	Micro-lectures are gaining popularity due to the COVID-19 pandemic because students prefer short, precise, concrete, and complete lectures.
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Problem	Micro-lectures are suitable for imparting concept understanding skills to students. However, due to short lecturing time they are generally not suitable for nurturing students' memorization and application skills.
Forces	According to Bloom's taxonomy, the prime objective of a lecturing process is to nurture students' memorization, understanding and application skills. However, due to short lecturing time, micro-lectures often fail to impart application and memorization skills to students. Can we design a micro-lecturing process capable of imparting all three skills to students?
Solution	To impart all three skills, dope MIL body and conclusion sections with pointers, pointing towards application and memorization areas concerning current MIL. Then use MTUTs to explain and implement these pointers (see Figure 2 (b)).
Examples	To check the validity of this pattern we floated a twenty-day-long 'C' programming course for 62 registered students. We used this pattern in association with MTUT to teach registered students and observed excellent results. For example, we observed a hike of more than 25% in students' problem-solving, application and programming skills.
Consequences	<ul style="list-style-type: none"> <li>• This pattern allows MILs to impart all three skills to students.</li> <li>• Apart from imparting all three skills, this pattern helps to highlight and rectify common errors made by students while solving some problems.</li> <li>• The pattern focuses on designing rhythmic MTUTs that ease students' learning process.</li> <li>• The limitation of this pattern is that designing MTUTs concerning application and memorization skills requires extensive planning, thereby making it a time-consuming process.</li> </ul>

#### 5.4 Modified Micro-Lecturing Process

The pattern discussed in section 5.4 and MTUT discussed in section 5.3 are collectively used to craft a modified version of the micro-lecturing process. This modified version can handle memorization, understanding and application skills simultaneously. Traditional micro-lectures have MIL components without pointers pointing to application and memorization areas (see Figure 2 (a)). However, we can dope the micro-lecture's body and conclusion components with pointers pointing to memorization and application areas concerning the current MIL. Micro-tutorials can easily handle these pointers (see Figure 2 (b)).

The complete modified micro-lecturing process (modified using patterns and MTUTs) is presented in Figure 2 (c). The process starts by identifying and classifying KPs associated with a topic to form KP-Hierarchy (see Figure 2 (c) step 0-step 1). Then traversal order is found, and KPs present in KP-Hierarchy are arranged in sequence (see Figure 2 (c) step 2). While forming MILs using sequentially arranged KPs, lecture designers must embed memorization and application pointers in the body and conclusion sections of the MILs. (see Figure 2 (c) step 3). These MILs help to enhance students understanding skills. Then for every MIL, a micro-tutorial is designed. This micro-tutorial help in explaining memorization and application pointers. These MTUTs also handle MIL components and help students to rectify common errors (see Figure 2 (c) step 4). Then Assignments are attached with MILs and MTUTs for practice purposes (see Figure 2 (c) step 5). This completes the modified micro-lecturing process. This process helps to enhance students' memorization, understanding and application skills simultaneously using MILs.

## 5.5 Validity of Modified Micro-Lecturing Process and Results

We floated a 20-day-long course on 'C' programming for 62 registered students to prove the validity of our proposed modified version of the micro-lecturing process. We used the modified micro-lecturing process discussed above for teaching them 'C' programming basics. We conducted pre-tests and post-tests to measure performance hikes concerning several programming parameters/skills.

These parameters/skills represent memorization, understanding and application skills. These parameters/skills are derived after an extensive literature survey in association with the Delphi study, conducted with the help of seven retired computer programming teachers. We also asked students to fill out a feedback form after every session. The selected parameters/skills are concept & syntax memorization, innovation & application, problem-solving, overall programming, concept understanding and error handling.

We observed a performance hike of 32% in concept understanding and overall programming skills. At the same time, problem-solving skills show a 31% hike and concept & syntax memorization skills show a 30% hike. We observed a 29% hike in error handling skills and 28% in innovation and application skills. Figure 3 (a) shows performance hikes concerning different programming skills.

We also asked students to rate every MIL concerning seven quality attributes using a 4-pointer scale {bad, average, good and excellent}. These quality attributes are concept understanding, concept memorization, concept application, simplicity, engaging, interesting, modified micro-lecturing process. We did an extensive literature survey to come up with these quality attributes. We observed that concerning **concept understanding** {0, 11, 22, 29} students rated MILs designed using the modified micro-lecturing process as {bad, average, good, excellent} respectively. Similarly concerning **concept memorization** {0, 8, 24, 30} students, **concept application** {1, 11, 24, 26} students, **simplicity** {0, 14, 26, 22} students, **engaging** {1, 14, 24, 22} students, **interesting** {1, 11, 26, 24} students and **modified micro-lecturing process** {2, 9, 29, 22} students rated MILs as {bad, average, good, excellent} respectively. Figure 3 (b) presents the ratings given by 62 students concerning seven quality attributes using a 4-pointer scale.

## 6. Conclusion

This research aims to modify the traditional micro-lecturing process to simultaneously enhance students' memorization, understanding, and application skills. This research highlights that the traditional micro-lecturing process can enhance students' understanding skills but fails to enhance students' application and memorization skills due to short lecturing time. This research uses the application & memorization pointer pattern (MLP pattern) to dope MIL components, namely body and conclusion sections with application and memorization pointers. The MIL components, pointers and error handling capabilities are explained and handled by MTUTs. Respective assignments follow these MTUTs for practice purposes. This complete modification of the micro-lecturing process helps us to address the research problem stated in this paper. To prove the validity of our proposed method, we floated a C programming course. We observed that students' memorization, understanding and application-related programming skills show a hike of more than 25%. We also noticed that majority of students rated this way of teaching as good or excellent on a four-pointer scale {bad, average, good, excellent}. We strongly believe that this research will help the education industry, MIL designers, and teachers design pedagogically effective micro-lectures.

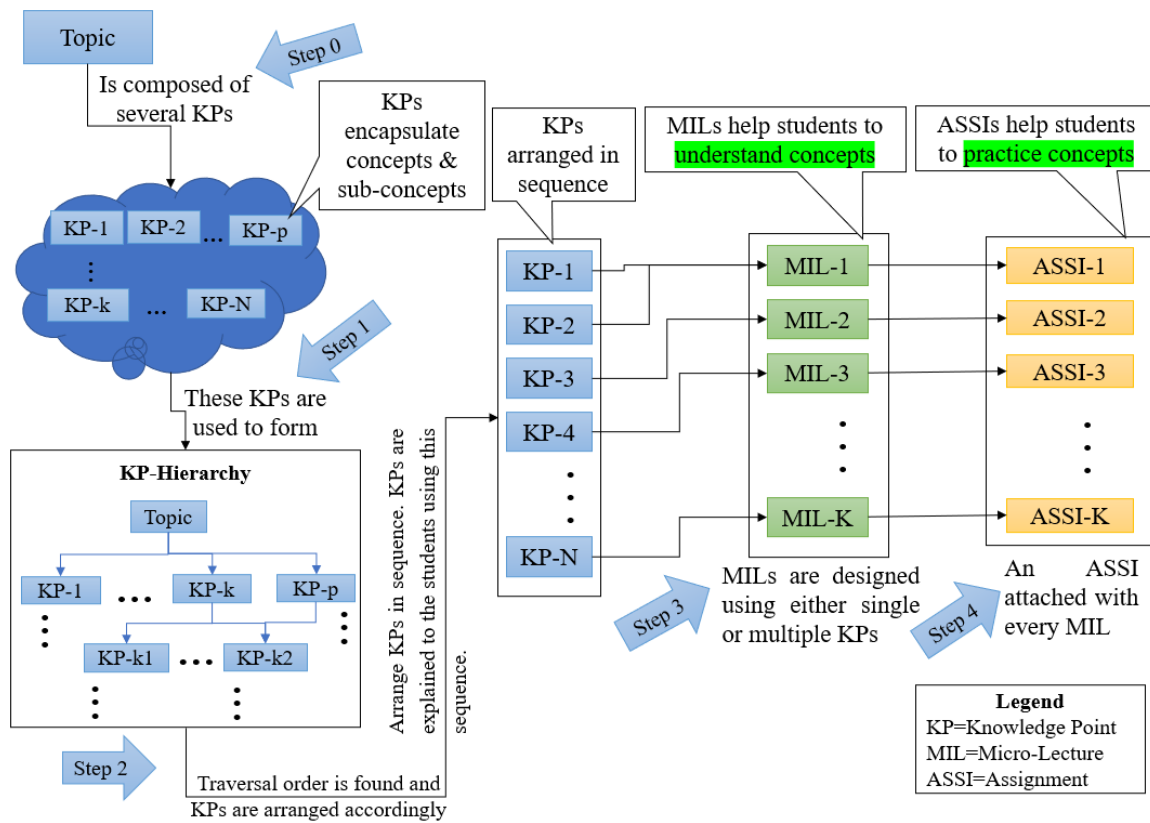


Figure 1: Traditional Micro-Lecturing Process

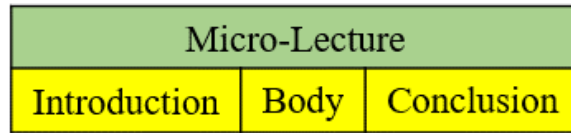


Figure 2 (a): Structure of Traditional Micro-Lecture.

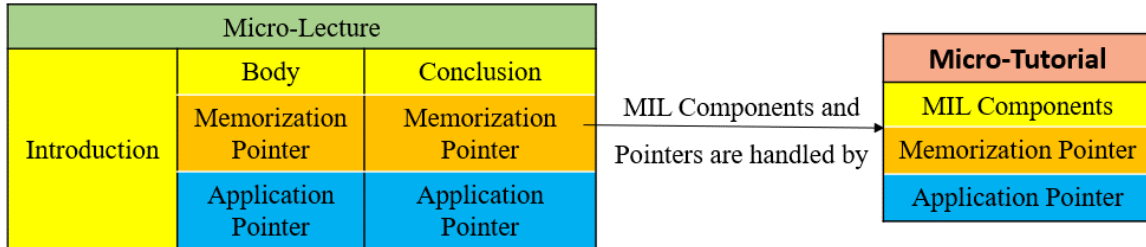


Figure 2 (b): Structure of Micro-Lecture Doped with Pointers and Relation Between MIL and MTUT.

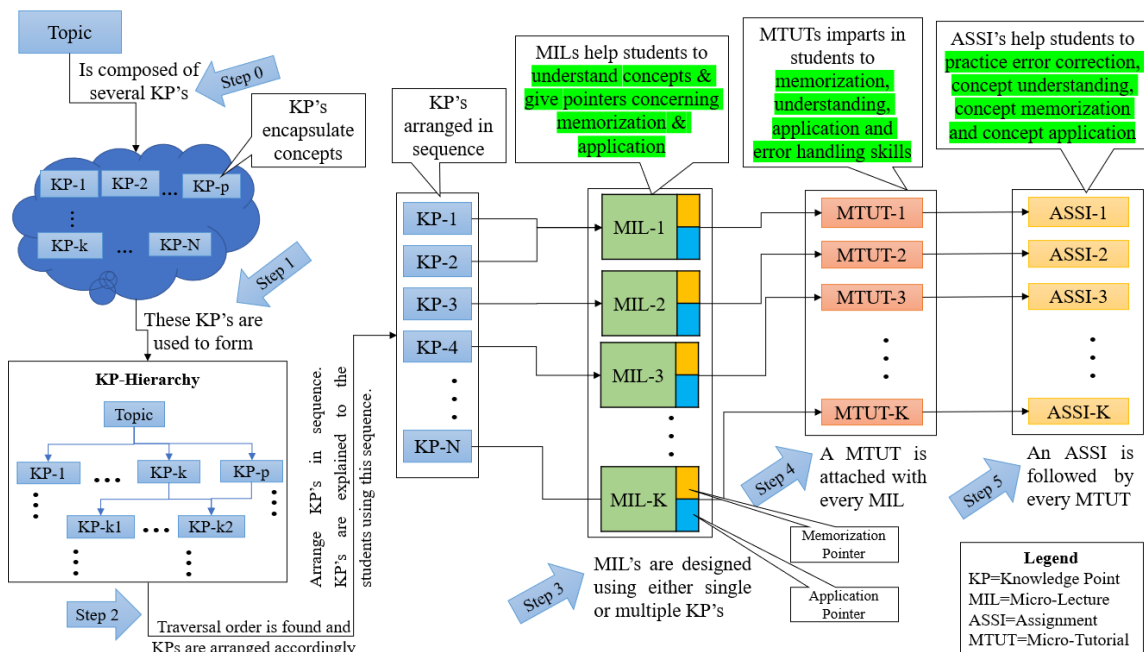


Figure 2 (c): Micro-Lecturing Process Modified Using Memorization & Application Pointer Pattern and Micro-Tutorials.

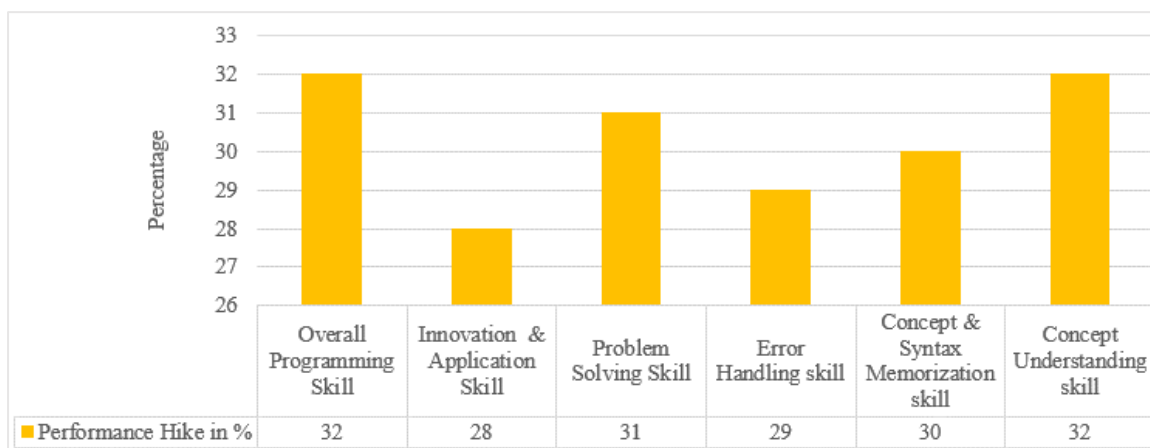


Figure 3 (a): Showing performance hike (in percentage) concerning several programming skills.

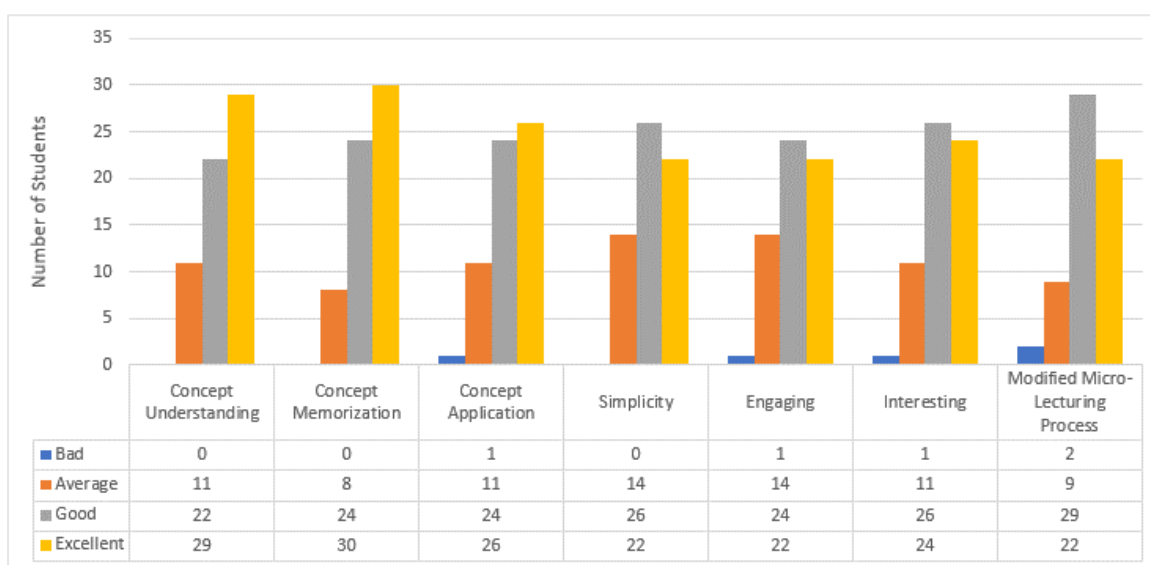


Figure 3 (b): Showing rating given by 62 students concerning seven quality attributes using 4-pointer scale {bad, average, good and excellent}.

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