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# Assessment of Psychomotor Domain in Materials Technology Laboratory Work

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**Abstract**

The learning domains (cognitive, affective and psychomotor) for each program outcome for the Civil and Structural Engineering (C and SE) program are identified. Two programs outcomes which are identified as the outcomes where the psychomotor leaning domains are to be developed in C and SE students. Key performance indicators are written so as to assess the student performance in achieving the identified outcomes. In Materials Technology course, the rubrics of the chosen key performance indicators for the laboratory work component of this course are prepared to assess the student psychomotor achievement in the subject.



*Keywords:* Laboratory work; materials technology; psychomotor domain

## 1. Introduction

The domains of learning as described by Bloom's Taxonomy are the cognitive, affective and psychomotor (Dooley et al., 2005). Most of the student's cognitive mental skills (Knowledge) are developed through classroom instruction. The student's affective skills component, a growth in feelings or emotional areas (Attitude), is developed through structured leadership in grouped design project (capstone), career development activities and events (co-curricular activities), competitions, cornerstone and final year project presentation and

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such. The student's psychomotor skills, commonly called manual or physical skills (Skills), are normally developed through laboratory setting. The Program Outcomes (PO) of the Civil and Structural Engineering Program (C and SE) are set as such to emphasize all three domains of learning. Table 1 shows the PO of the C and SE program and their allocated domains of learning.

Table 1. The program outcomes of the civil and structural engineering program and their allocated learning domain

| PO | Knowledge Components | Domain |
|---|---|---|
| 1 | Has adequate background knowledge and able to apply it | Cognitive |
| 2 | Has the ability to undertake engineering problem identification and provide solutions | Cognitive |
| 3 | Has the ability to design a Civil and Structural or Environmental Engineering project within social and environmental constraints. | Cognitive |
| 4 | Is able to behave professionally and practice moral ethics | Affective |
| 5 | Has the ability to design and conduct experiments, as well as to analyse and interpret data. | Cognitive and Psychomotor |
| 6 | Has the ability to use the techniques, skills and modern engineering tools necessary for civil engineering practice | Cognitive and Psychomotor |
| 7 | Has the ability to convey spoken or written ideas not only with engineers but also with community | Affective |
| 8 | Has the ability to function effectively as an individual and in a group with capacity to be a leader or manager as well as effective team member | Affective |
| 9 | Recognizes the needs of lifelong learning | Cognitive |
| 10 | Has the ability to adopt elements of construction project management, asset management, public policy, administration, business and entrepreneurship. | Cognitive |

Materials Technology (coded KKKH2164) course is a first semester second year course taught at the Department of Civil and Structural Engineering at Universiti Kebangsaan Malaysia (UKM). The course deals with the introduction of construction materials, their manufacturing processes, their characteristics and properties. This course consists of lectures; project; and laboratory work on the concrete mixing and testing. The mix design method of concrete (the most widely used construction material) is emphasized. The improvement on the delivery methods of the class instruction and the laboratory work were described previously (Hamid et al., 2008, Hamid et al., 2009 and Hamid & Mohammed, 2010). The assessment of the final examination questions was also analyzed elsewhere (Hamid et al. 2011). This paper describes the improvement in the laboratory work report assessment to include the assessment of the psychomotor domain. Previously, the laboratory report was assessed based on the cognitive domain only. Key performance indicators for each level in the psychomotor domain identified for this course are determined and the assessment rubrics for each level are prepared.

## 2. Key Performance Indicators

There are 8 levels in the psychomotor domain as shown in Table 2 (Simpson, 1972). Table 3 shows that action verbs provided for levels mechanism and complex overt response are the same, as such in this paper both level are labelled as Level 4. The key performance indicators written for the Material Technology lab report assessment should include adverbs or adjectives that will indicate that the performance is quicker, better, more accurate, and so forth.

Table 2. Psychomotor domain levels and verbs

| Perception (Level 1) | Set (Level 2) | Guided response (Level 3) | Mechanism (Level 4) | Complex Overt Response (Level 4) | Adaption (Level 5) | Origination (Level 6) |
|---|---|---|---|---|---|---|
| Sense organs guide motor activity | Readiness to take actions | Institution; trial and error | Do alone in less time without describing the steps; responses become habitual; move with some confidence and proficiency | Do without error; skilful performance of motor acts that involve complex movement patterns; performing without hesitation; quick; accurate; and highly coordinated performance | Do in a different way; skills are well developed and can be modified to fit special requirements | Do in a new way; create new movement pattern to fit a particular situations or problem; highly developed skills |
| Choose | Begin | Copy | Assemble | Assemble | Adapt | Arrange |
| Describe | Display | Trace | Calibrate | Calibrate | Alter | Build |
| Detect | Explain | Follow | Construct | Construct | Change | Combine |
| Differentiate | Move | React | Dismantle | Dismantle | Rearrange | Compose |
| Draw | Proceed | Response | Display | Display | Re- | Construct |
| Feel | React | Respond | Fasten | Fasten | organize | Create |
| Identify | Show | watch | Fix | Fix | Revise | Design |
| Isolate | State | | Grind | Grind | Vary | Initiate |
| Relate | Volunteer | | Heat | Heat | | Make |
| select | | | Manipulate | Manipulate | | Organize |
| | | | Measure | Measure | | |
| | | | Mix | Mix | | |
| | | | Sketch | Sketch | | |

Table 3 shows the key performance indicator (KPI) for PO5 (has the ability to design and conduct experiments, as well as to analyse and interpret data) which its learning domains are cognitive and psychomotor. When writing the key performance indicator for the psychomotor domain, according to [1], we must remember: (1) that a level of terminal behaviour is expected and accepted as evidence, (2) the conditions under which that desired or expected behaviour to occur must be defined, and (3) criteria of acceptable performance must be established by describing how well the learner must perform in order for that performance to be considered acceptable. When preparing the KPI for the psychomotor learning domain in Material Technology course, the highest level of the domain are assessed since the students are expected to have achieved the lower level to arrive to the higher competency level.

Table 3. Key Performance Indicator for Program Outcome 5

| Code | Key Performance Indicator | Learning Domain |
|---|---|---|
| (5C5) | Ability to design experiment based on the research objective | Cognitive |
| (5C2) | Ability to observed and gather data | Cognitive |
| (5C4) | Ability to analyse data | Cognitive |
| (5C6) | Ability to present data in graphical form | Cognitive |
| (5C6) | Ability to interpret data critically | Cognitive |
| 5C6) | Ability to infer such as able to conclude and explain the phenomenon occurred during experiment | Cognitive |
| (5P5) | Ability to perform experiment successfully without supervision | Psychomotor |
| (5P5) | Ability to organise and perform experiment safely and aware of priority in the workplace | Psychomotor |
| (5P6) | Ability to revise procedures and adapts the experiment tools to meet a problem situation | Psychomotor |

## 3. Assessment Rubric

The assessment rubrics for the KPIs in Table 3 were prepared as in Appendix A. Appendix A shows that the psychomotor learning domain are also assessed for the laboratory work component of the Material Technology course as stated in the program outcomes of the Civil and Structural Engineering program.

## 4. Conclusion

The learning domains (cognitive, affective and psychomotor) for each program outcome for the Civil and Structural Engineering program are identified. Program outcomes 5 and 6 are identified as the outcomes where psychomotor leaning domains are to be developed in C and SE students. Key performance indicators are written so as to assess the student performance in achieving PO5. For Materials Technology course, the rubrics of the chosen key performance indicators for the laboratory work of this course are prepared to assess the student psychomotor achievement in the subject.

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## Appendix A - LABORATORY - GROUP REPORT EVALUATION

Laboratory: _____ Course: _____ Group no.: _____

Title of project/ problem: _____ Report due date: _____

Group members: 1) _____ 2) _____

3) _____ 4) _____ 5) _____

| No | Criteria | 4<br>Excellent | 3<br>Good | 2<br>Fair | 1<br>Poor | Score | KPI |
|---|---|---|---|---|---|---|---|
| 1 | Abstract / Executive report<br>*Short statement on purpose of work, pertinent conditions, results in brief* | The abstract is generally solid (all main points present) | Only two main points of the abstract is present | Only one main point of the abstract is present | All main points of the abstract are not present | | 5C4 |
| 2 | Project Introduction, Background & Problem Statement | • Good project introduction with supportive evidence and substance<br>• Background information is very relevant and provides a very clear lead-in to the research problem<br>• Problem statement articulated very clearly & well supported/justified by theory and/or past research | • Good project introduction<br>• Background information is relevant and provide a clear lead-in to research problem<br>• Problem statement articulated clearly and supported/justified by theory and/or past research | • Fair project introduction<br>• Background information is relevant and provide a fair lead-in to research problem<br>• Problem statement articulated clearly but only fairly supported/ justified by theory and/or past research | • Very brief project introduction<br>• Background information somewhat relevant but does not provide a clear lead-in to the research problem<br>• Problem statement not articulated clearly and hardly supported/ justified by theory and/or past research | | 5C6 |
| 3 | Procedures<br>*Steps taken, method used, circuit diagrams, design calculations, flow chart etcs* | Presents easy-to-follow steps which are logical and adequately detailed. | Most of the steps are understandable; some lack detail or are confusing. | Some of the steps are understandable; most are confusing and lack detail. | Not sequential, most steps are missing or are confusing. | X 1.5 | 5C6 |
| 4 | Data & Results<br>*Results in the form of data, graphs etc.* | Data table and graph neatly completed and totally accurate. | Both accurate, some ill-formed characters. | Both complete, minor inaccuracies and/or illegible characters. | Data table and/or graph missing information and are inaccurate. | X 2 | 5C2 |
| | Findings & Discussion | •The discussion soundly interprets the findings and is carefully connected with other sections of the report such as the background, problem statement, research questions, instruments and results.<br>•The findings are judiciously discussed in relation to theory and findings of past studies cited in literature review.<br>•Implications, recommendations and directions for future research are carefully drawn from the research findings.<br>•Limitations of the study are relevant | •The discussion interprets the findings and is connected with other sections of the report such as the background, problem statement, research questions, instruments and results.<br>•The findings are either superficially discussed or not discussed in relation to theory and findings of past studies cited in literature review.<br>• Implications, recommendations and directions for future research are drawn from the research findings.<br>• Limitations of the study are relevant and adequately described. | •The discussion fair interprets the findings and is connected with other sections of the report such as the background, problem statement, research questions, instruments and results.<br>•The findings are either fairly discussed or not discussed in relation to theory and findings of past studies cited in literature review.<br>•Implications, recommendations and directions for future research are fair drawn from the research findings.<br>•Limitations of the study are relevant | •The discussion may be incomplete or partially/ not clearly connected to the results. The connection with other sections is vague.<br>•The findings presented are mere repetitions of the results without appropriate interpretation<br>•Implications, recommendations and directions for future research are not drawn from the research findings.<br>•Limitations of the study are irrelevant. | X 2 | C6 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | and extensively described. | | and adequately described. | | | |
| 6 | Conclusion<br>*Provide answers to objectives stated earlier* | The closing paragraph summarizes and draws a clear and well developed conclusion | The closing paragraph summarizes and draws a sufficiently supported conclusion | The closing paragraph attempts to summarize but draws a weak conclusion | Concluding paragraph is not apparent | | 5C6 |
| 7 | Writing format and style | Precise and reasonable | Effective, contains very few errors | Contents many errors that garble the meaning or intent | Contains serious and multiple errors that hinder readability | | 5C6 |
| 8 | Group Organization | •Excellent work planning<br>•More than four times of meetings are conducted | • Good work planning<br>• Three times of meetings are conducted | • Fair work planning<br>•Two times of meetings are conducted | • Poor work planning<br>• One or no meetings are conducted | | A |
| 9 | Ability to perform experiment successfully without supervision | Able to perform all experiments without assistance and supervision successfully and safely. | Able to perform 80% of the experiments without assistance and supervision successfully and safely. | • Able to perform 50% of the experiments without assistance successfully and safely.<br>• Able to perform the experiment safely under supervision | Not able to perform the experiment without assistance and supervision | | 5P5 |
| 10 | Ability to organise, and perform experiment safely and aware of priority in the laboratory | • Able to perform experiments safely without supervision and assistance; work in a group effectively<br>• Able to determine the priority of the laboratory environment<br>• Supervise own work in achieving experimental objectives | • Able to perform experiments safely without supervision; seek for assistance<br>• Able to determine the priority of the laboratory environment<br>• Perform experiments based on protocol and procedures and understand the problem statement; critical on the reasons for doing experiments and strategised effectively | • Able to perform experiments safely with 50% assistance<br>• Able to perform experiments safely with continuous supervision<br>• Understand the problem statement and ask questions<br>• Perform experiments based on protocol and procedures and understand the problem statement; not critical on the reasons for doing experiments and do not strategised effectively. | • Fail to identify the important information in the laboratory<br>• Need continuous assistance (100%)<br>• Not being able to decide on their own<br>• Unsafe work<br>• Do not ask around for assistance | | 5P5 |
| 11 | Ability to revise procedures and adapts the experiment tools to meet a problem situation | • Able to utilize the experimental apparatus without assistance confidently<br>• Understand the apparatus' method of principle<br>• Able to utilize experimental apparatus other than normal practice<br>• Utilize experimental apparatus creatively and innovatively | • Able to utilize the experimental apparatus without assistance confidently<br>• Understand the apparatus' method of principle | • Not confident; need assistance but can perform experiments own their own<br>• Follow normal procedures without understanding the apparatus' method of principle | • Not confident in utilizing the apparatus<br>• Need assistance continuously | | |