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# Implementation of Personalized E-Assessment for Remedial Teaching in an E-Learning Environment

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**ABSTRACT**
This research explored how different models of Web-based dynamic assessment in remedial teaching improved junior high school student learning achievement and their misconceptions about the topic of 'Weather and Climate.' This research adopted a quasi-experimental design. A total of 58 7th graders participated in this research. Participants were divided into the experiment group (28 participants) and the control group (30 participants). The experiment group took the 'personalized Web-based dynamic assessment' while the control group took the 'non-personalized Web-based dynamic assessment.' The two groups of students received the same lessons via conventional teaching prior to the experiment, and after the lessons were completed, they both took the pre-tests of the achievement test and the two-tier diagnostic test. After the tests, different models of Web-based dynamic assessment were administered to facilitate student learning. Once the Web-based dynamic assessments were accomplished, the two groups of students took the post-tests of the achievement test and the two-tier diagnostic test. Research findings reveal that students in the experiment group experience significantly better improvement in their learning achievement and misconceptions.
**Keywords:** GPAM-WATA, Web-based dynamic assessment, e-assessment, misconception, weather and climate

## INTRODUCTION

Assessment should evolve with information communication technology and the diversification of teaching. Conventional achievement tests center on test results, which represent a learner's overall learning performance, and do not provide sufficient information on the learner's cognitive processes. By contrast, dynamic assessment is able to offer a solution to these problems. The theoretical basis of dynamic assessment is the 'Zone of Proximal Development (ZPD)' proposed by L. S. Vygotsky (Elliott, 2003; Haywood, Brown, & Wingenfeld, 1990; Wang, 2014).


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**State of the literature**

- The environment of e-assessment allows learners to interact with the assessment system directly, and receive timely feedback when they encounter difficulties during the evaluation, encouraging learners to actively participate in self-assessment and enhancing learning outcomes.
- Web-based dynamic assessment is found to be effective in improving student learning. The 'graduated prompt approach' is an effective dynamic assessment approach in facilitating student learning in an e-Learning environment.
- The key to the 'graduated prompt approach' is to deliver instructional interventions with personalized prompts. Prompts are gradually provided, with general prompts given first, followed by specific prompts. This offers examinees an overview of their learning condition or opportunities to improve their misconceptions.

**Contribution of this paper to the literature**

- Personalized Web-based dynamic assessment is administered based on the Web-based two-tier diagnostic assessment. With the personalized Web-based dynamic assessment, students have better learning effectiveness in the topic of 'Weather and Climate'.
- This research proposed an e-assessment model, GPAM-WATA, which is effective in improving student learning effectiveness and misconceptions about the topic of 'Weather and Climate'.
- GPAM-WATA may improve students' sensitivity to the environment, and make students care more about the environmental issues about climate change.

ZPD refers to the difference between the cognition level learners can achieve with and without the assistance of teachers and outstanding peers (Elliott, 2003; Vygotsky, 1978; Wang, 2010; 2011; 2014). Dynamic assessment is an interactive assessment and differs from conventional assessment methods. Haywood, Brown & Wingenfeld (1990) argued that conventional assessment evaluates, instead of attempting to change, examinee performance, while dynamic assessment measures the learning process and the dynamics of learner's cognitive ability. Dynamic assessment emphasizes the individual learning process, and offers prompts to examinees during assessment, combining the 'test-teach-retest' practice (Moore-Brown, Huerta, Uranga-Hernandez, & Peña, 2006), which optimizes individual performance (Wang, 2008; 2010; Sternberg & Grigorenko, 2001). In other words, the main purpose of dynamic assessment is improving learner performance through assistance of assessment activities (Elliott, 2003; Sternberg & Grigorenko, 2001).

The above description of dynamic assessment shows that to administer such an assessment well requires that the teacher deal with learners on an individual basis. However, a teacher in practice must simultaneously teach many students and is pressured to follow a teaching schedule (Buchanan, 2000; Wang, 2008 Wang, 2011), which tends to make it challenging to administer dynamic assessment. Now, the environment of e-assessment allows learners to interact with the assessment system directly, and receive timely feedback

when they encounter difficulties during the evaluation, encouraging learners to actively participate in self-assessment and enhancing learning outcomes (Wang, 2008). Wang (2010, 2011) developed the Graduated Prompting Assessment Module of the WATA system (GPAM-WATA) and designed dynamic assessment items and prompts following the 'graduated prompt approach' of Campione & Brown (1985, 1987). Campione and Brown (1985, 1987) proposed the 'graduated prompt approach' to develop and perform dynamic assessment. The key to the 'graduated prompt approach' is to deliver instructional interventions with personalized prompts (Campione & Brown, 1985, 1987; Wang, 2014). Campione & Brown argued that the purpose of dynamic assessment lies not in evaluating existing knowledge, skills and experiences, but in the learner's growth, change, and in their learning conditions. Dynamic assessment per se is a dynamic process in which learners are given instant appropriate prompts when faced with difficulties during the assessment. This offers examinees an overview of their learning condition or opportunities to improve their misconceptions. Prompts are gradually provided, with general prompts given first, followed by specific prompts. 'General prompts' are less related to the answers and not specific, while 'specific prompts' provide learners complete guidance to the answers (Compione & Brown, 1985; 1987, pp. 92-95). Wang (2010; 2011) applied GPAM-WATA to the teaching of mathematics and biology, and found that GPAM-WATA has positive effects on learning outcomes, especially for learners with low-level prior knowledge.

This research also adopts GPAM-WATA, and it further administers a two-tier diagnostic test along with dynamic assessment, creating personalized dynamic assessment. The two-tier diagnostic test is often used in the fields of mathematics and science education to investigate learner misconceptions and to assist instructors in understanding learner entry behavior and planning and designing following curriculum (Treagust, 1995). Each item in the two-tier diagnostic test is composed of two-tier multiple-choice questions. Questions in the first tier primarily test student judgment on a certain subject, while questions in the second tier examine why students gave the answers to the first-tier questions, making it possible to understand and analyze student ideas in a short span of time (Treagust, 1995). Since two-tier diagnostic tests can diagnose learner misconceptions, this research leverages them to gather concepts that learners need in order to enhance their learning, and automatically assemble a personalized dynamic assessment for each learner, based on the results of the two-tier diagnostic test. The personalized dynamic assessment allows learners to focus on items about the concepts that they need to enhance learning, and to learn from the graduated prompts and feedback.

This research applies GPAM-WATA to the remedial teaching of the topic of 'Weather and Climate' in junior high school, and examines the effectiveness of the Web-based dynamic assessment which uses personalized and non-personalized models for remedial teaching. There are two research questions:

1. What is the effectiveness of the personalized and non-personalized Web-based dynamic assessment in improving student learning achievement about the topic of 'Weather and Climate'?

2. What is the effectiveness of the personalized and non-personalized Web-based dynamic assessment in improving student misconceptions about the topic of 'Weather and Climate'?

## METHODOLOGY

### Participants

This research adopts convenience sampling and selects two classes of 7th graders from a junior high school as participants, composed of 27 male and 31 female students, totaling 58 participants. Both classes are of normal class grouping. It divides the two subject classes randomly into the experiment group of 28 participants (14 male and 14 female) and the control group of 30 participants (13 male and 17 female).

### Instruments

#### *Learning contents*

The learning contents of this research consist of the topic of 'Weather and Climate' in junior high school courses in Taiwan. This topic can be broken down to five parts: 'understanding the difference between weather and climate,' 'learning about elements of weather,' 'factors influencing Taiwan's climate,' 'recognizing the features of Taiwan's climate,' and 'knowing Taiwan's climate damages.'

#### *Achievement test*

Achievement test is employed for both pre- and post-tests to understand student learning achievement on the topic of 'Weather and Climate' before and after the experiment. To ensure the reasonableness of the items and satisfy the purpose of the experiment, this achievement test is reviewed by senior junior high school teachers and experts in assessment and science education. The discrimination index of all 25 items is above 0.30, the average difficulty index is 0.68, and the internal consistency reliability (Cronbach α) is 0.89.

#### *Two-tier diagnostic test*

Two-tier diagnostic test is a diagnostic tool for misconceptions proposed by Tregust (1995). The approach is twofold: the first tier of items is made of multiple-choice questions that essentially test student's concepts on the subject to understand their level of knowledge; the second tier is composed of questions that call for reasons or rational inference for the answers given in the first phase to enable the student's ideas to be better known. This research uses multiple-choice questions in both tiers. Twenty items whose discrimination index are all above 0.30 comprise the two-tier diagnostic test. The screenshot of the two-tier

diagnostic test is shown in **Figure 1.** Two-tier diagnostic assessment is implemented on both the pre- and post-tests to examine student improvement in their misconceptions about the topic of 'Weather and Climate.'

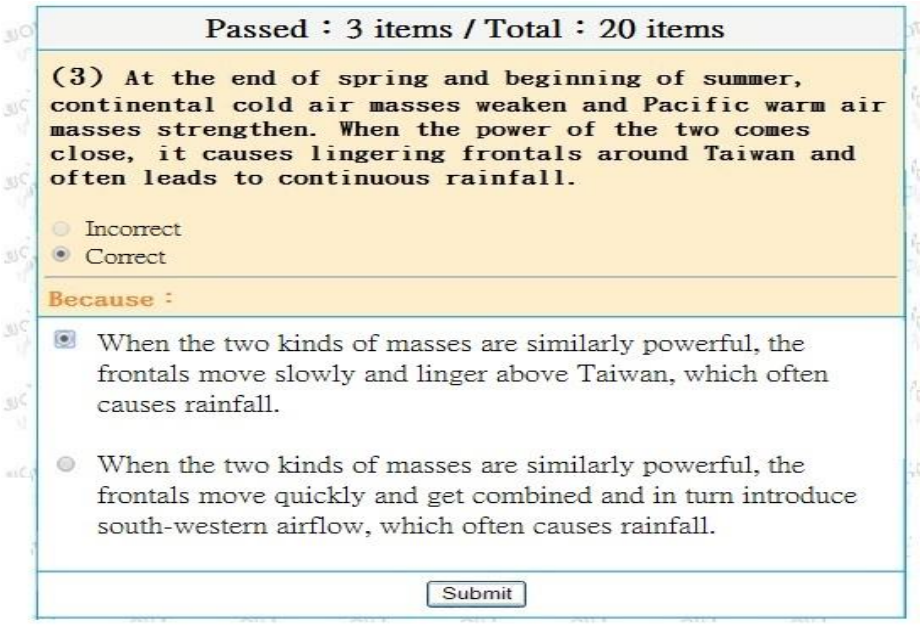


**Figure 1.** Two-tier diagnostic assessment item in GPAM-WATA

### *Web-based dynamic assessment - GPAM-WATA*

Taking up the 'graduated prompt approach (Campione & Brown, 1985; 1987)', the items and prompts in the GPAM-WATA (Wang, 2010; 2011; 2014) follow a standardized principle in which general, abstract prompts are followed by specific, concrete ones. Through prompts given during student participation in Web-based dynamic assessment, students are provided with assistance in guiding them to answer items to improve their learning. The prompts are scaffolds that facilitate student learning and clarify their misconceptions at the same time. This research adopts the GPAM-WATA to administer personalized Web-based dynamic assessment. Its delivery approach is as follows: after the learner logs in to the system, the two-tier diagnostic test will first be administered. Referring to the items the learner answers incorrectly in the two-tier diagnostic test, GPAM-WATA will assemble a set of personalized dynamic assessment. In other words, when answering their personalized dynamic assessment items, learners are able to concentrate on those concepts they have a weaker understanding of, and gain further learning opportunities via taking dynamic assessment and receiving prompts (Wang, 2014). Because of their instructional nature, dynamic assessment items and prompts are respectively termed as 'instructional item (II)' and 'instructional prompt (IP)' (Wang, 2010; 2011). The control group, in contrast, are lack of personalized mechanism and learners are required to complete all dynamic assessment

items. In other words, GPAM-WATA does not assemble personalized dynamic assessment based on the results of the two-tier diagnostic test.

Dynamic assessment in this research has 40 items, and each item includes three instructional prompts (IPs). The IPs are designed following Wang (2011), whose approach is adapted from the 'mathematical problem-solving theory' of Mayer (1992). **Table 1** shows the design principles and examples of the instructional prompts embedded in the Web-based dynamic assessment items in this research.

**Table 1.** The design principle of IPs of dynamic assessment item

Question: If the temperature drops 0.6 degrees for every 100 meter rise in altitude, what is the approximate temperature at the top of Mt. Ali at 2000 meters in altitude?

| Phases | Design principle (Wang, 2011) | Design principle in this research | Content of Prompts |
|---|---|---|---|
| $IP_1$ | Explanations of problems, helping learners to clarify conditions | Explanation of questions, to assist students with clarification of required elements | Ground refers to sea level at 0 meters in altitude, thus what would be the temperature with the altitude rising from 0 meters to 2000 meters and a starting temperature of 20 degrees? |
| $IP_2$ | Key concepts | Cues of key concepts (including the finding of key words in the item) | 1. This is a concept about the influence of geography on temperature, that the higher the terrain is, the lower the temperature is.<br>2. Temperature drops 0.6 degrees for every 100 meters rise in altitude, thus how many degrees will the temperature drop with a rise of 2000 meters in altitude? |
| $IP_3$ | Demonstrating how to solve a similar problem with simplified numbers or performing direct instruction | Provision of simplified numbers and calculation of solving similar questions, or direct teaching | Temperature drops 1000/100=10, 0.6*10=6 degrees with a rise of 1000 meters in altitude. Thus, the temperature is 20-6=14 degrees |

## Research design and procedure

This research adopts a quasi-experimental design. The two participating classes are randomly divided into the experiment group and control group. All students receive

conventional teaching on the topic of 'Weather and Climate' in conventional classrooms from the same teacher based on the same instructional content. Students of both the experiment group and the control group take a Web-based dynamic assessment after they complete the pre-test of the achievement test and the pre-test of the two-tier diagnostic test in GPAM-WATA. After completing their Web-based dynamic assessment in GPAM-WATA, all students take the post-test of the achievement test and the post-test of the two-tier diagnostic test so that student learning achievement and their improvement in misconceptions can be examined.

The difference of the experiment and control groups lies in whether the personalized Web-based dynamic assessment is applied. Students of the experiment group take personalized Web-based dynamic assessment, and those of the control group are given identical items and prompts, but with a non-personalized approach. Based on the results of two-tier diagnostic test, the GPAM-WATA assembles the items of the dynamic assessment for each student in the experiment group. In other words, students in the experiment group just need to answer the items they have to practice to enhance learning. These items are related to the concepts they need to enhance their understanding. However, students in the control group must answer all of the dynamic assessment items. During the course of administering Web-based dynamic assessment, teachers are able to provide learners with teaching assistance using the instructional prompts in GPAM-WATA, and in turn advance their learning performance. When a student gives an incorrect answer for a certain item for the first time, GPAM-WATA will give a prompt before displaying the next item, after which GPAM-WATA will later again randomly display items the student answers incorrectly. If the student gives an incorrect answer again, GPAM-WATA will provide another graduated prompt for the second time, before moving on to other items, and then randomly returning to the same item. Each time students are given different graduated prompts, which are meant to guide them to find the correct answer step by step. When the student fails to give the correct answer after getting three prompts, the particular item will not be displayed again. GPAM-WATA will identify a student's inability to answer such an item. Screenshots of a sample item and prompt in the dynamic assessment are shown in **Figure 2** and **Figure 3.**

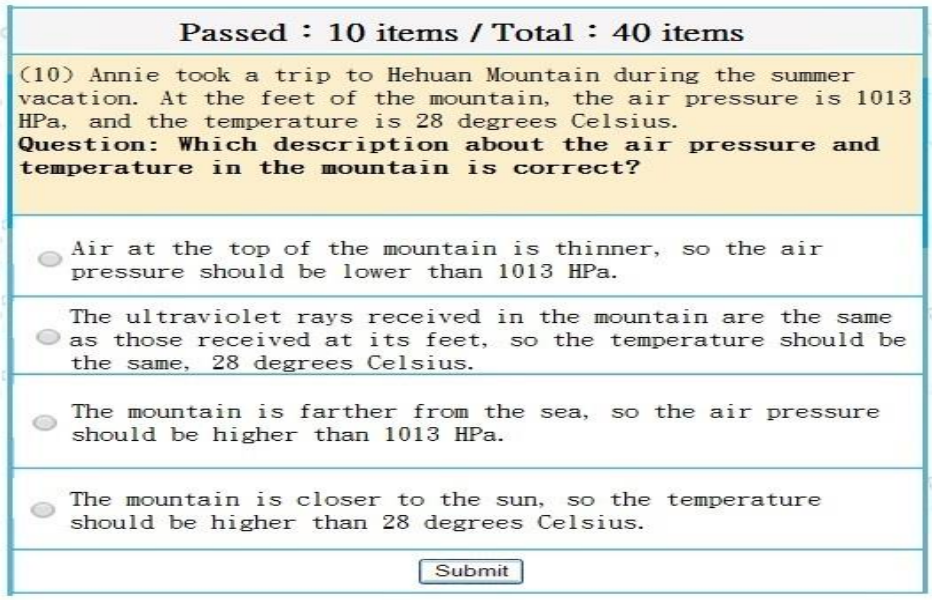


**Figure 2.** Dynamic assessment item in GPAM-WATA

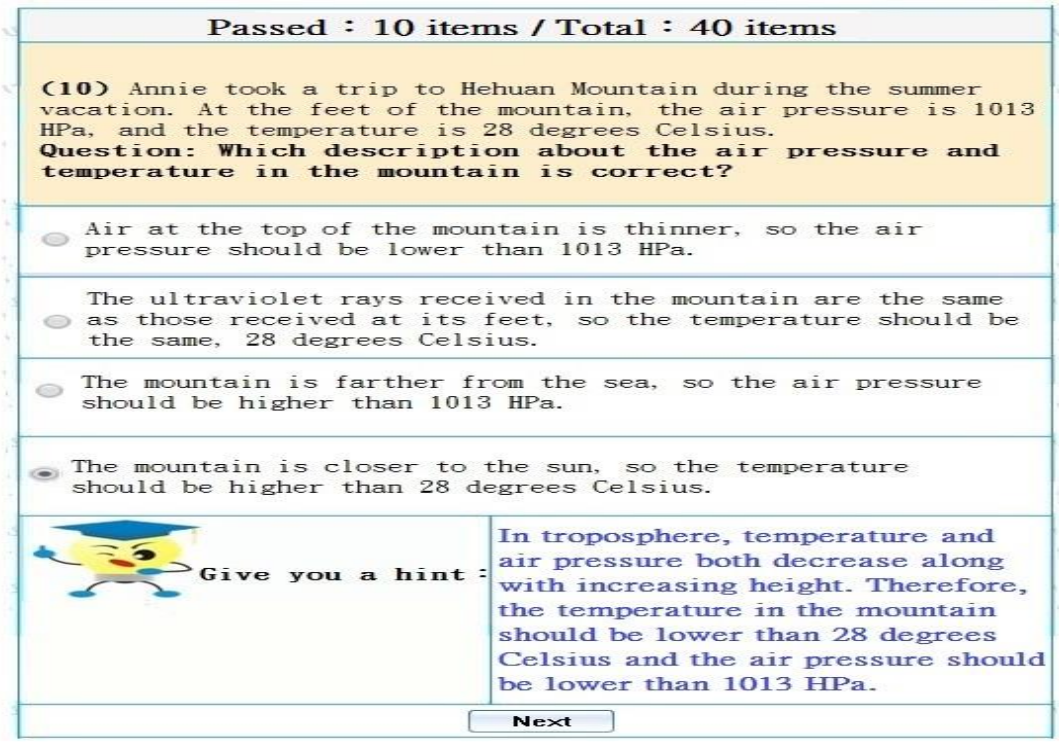


**Figure 3.** Prompt of the dynamic assessment item in GPAM-WATA

### Data collection and analysis

This research explores student learning achievement and their improvement in the misconceptions using two different Web-based dynamic assessments adopting personalized and non-personalized models. The pre-tests of the 'achievement test' and 'two-tier diagnostic test' are administered after all students receive conventional teaching in a conventional classroom. These are used to evaluate student entry behavior and misconceptions before they take the Web-based dynamic assessment. After the treatment, all students take the post-tests of the 'achievement test' and 'two-tier diagnostic test' to know their learning achievement and improvement in the misconceptions.

Pre-test and post-test scores are all quantified data. SPSS For Windows Ver. 19.0 is used to perform data analysis. Descriptive statistical analysis, paired samples t test, and one-way ANCOVA are used to examine whether the two groups of students exhibit significant differences in their learning achievement and improvement of the misconceptions after taking different models of Web-based dynamic assessment. During one-way ANCOVA, the pre-test scores are taken as the covariate, models of Web-based dynamic assessment (personalized and non-personalized models) as the fixed factor, and post-test scores as the dependent variable.

## RESULTS

### Effectiveness on improving student learning achievement using different models of Web-based dynamic assessment

**Table 2** shows descriptive statistics of student performance in the pre-test and post-test of the achievement test. It shows that both personalized ($t=7.824$, $p<0.01$) and non-personalized ($t=3.513$, $p<0.01$) Web-based dynamic assessments help students of the two groups achieve significantly better post-test scores than pre-test scores, which means the two models of Web-based dynamic assessment are both helpful in improving student learning achievement.

**Table 2.** Descriptive statistics of the pre-test and post-test scores of the achievement test

| Groups | Pre-test | | Post-test | | t value |
|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | |
| **Experiment group (n=28)** | 64.61 | 16.51 | 72.78 | 14.79 | 7.824** |
| **Control group (n=30)** | 61.57 | 13.63 | 64.93 | 14.89 | 3.513** |

**p<0.01; the full scores of the achievement test is 100.

One-way ANCOVA is also conducted to investigate the effectiveness of the personalized and non-personalized models of Web-based dynamic assessment on improving student learning achievement. Before one-way ANCOVA, the homogeneity of variance assumption was tested. The Levene's test for equality of variances was not significant ($F=3.708$, $p> 0.05$). In addition, the assumption of homogeneity of regression coefficients was also tested ($F=0.579$, $p>0.05$). These results indicated that neither homogeneity assumption was violated. For the results of one-way ANCOVA, please see **Table 3.**

**Table 3** shows that the pre-test scores on the achievement test (PRE) have a significant impact on the post-test scores of the achievement test ($F=384.551$, $p < 0.01$), as does the 'GROUP' ($F=13.044$, $p < 0.01$). This means that students in the experiment and control groups are significantly different in their learning achievement on the topic of 'Weather and Climate.' The LSD post hoc test indicates that students in the experiment group, who take the personalized Web-based dynamic assessment, have significantly better learning achievement than students in the control group, who take the non-personalized Web-based dynamic assessment.

**Table 3.** One-way ANCOVA analysis on student learning achievement in two different Web-based dynamic assessment models (n =58).

| Source | SS | df | MS | F value | Posthoc |
|---|---|---|---|---|---|
| **PRE[a]** | 10794.683 | 1 | 10794.683 | 384.551** | |
| **GROUP** | 366.164 | 1 | 366.164 | 13.044** | Experiment group > Control group |
| **Error** | 1543.898 | 55 | 28.071 | | |
| **Corrected total** | 13231.586 | 57 | | | |

**p<0.01; [a] pre-test scores of the achievement

## Effectiveness on improving student misconceptions using different models of Web-based dynamic assessment

**Table 4** shows descriptive statistics of student performance on the pre-test and post-test of the two-tier diagnostic test. It shows that both personalized ($t=6.344$, $p<0.01$) and non-personalized ($t=4.958$, $p<0.01$) Web-based dynamic assessments in remedial teaching significantly improve students' misconceptions about the topic of 'Weather and Climate.'

**Table 4.** Descriptive statistics of the pre-test and post-test scores of the two-tier diagnostic test

| Groups | Pre-test | | Post-test | | t value |
|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | |
| **Experiment group (n=28)** | 9.89 | 2.91 | 11.82 | 3.28 | 6.344** |
| **Control group (n=30)** | 8.63 | 3.16 | 9.80 | 3.07 | 4.958** |

****p<0.01; the full scores of the two-tier diagnostic test is 20.**

To further understand how personalized and non-personalized models of Web-based dynamic assessment improve students' misconceptions about 'Weather and Climate,' one-way ANCOVA is conducted. Before one-way ANCOVA, the homogeneity of variance assumption was tested. The Levene's test for the equality of variances was not significant (F=0.520, p> 0.05). In addition, the assumption of homogeneity of regression coefficients was also tested (F=0.770, p>0.05). These results indicated that neither homogeneity assumption was violated. For the results of the one-way ANCOVA, please see **Table 5.**

**Table 5.** One-way ANCOVA analysis on students' improvement on misconceptions about 'Weather and Climate' in two different Web-based dynamic assessment models (n =58).

| Source | SS | df | MS | F value | Posthoc |
|---|---|---|---|---|---|
| **PRE[a]** | 447.440 | 1 | 447.440 | 213.128** | |
| **GROUP** | 10.029 | 1 | 10.029 | 4.777* | Experiment group > Control group |
| **Error** | 115.467 | 55 | 2.099 | | |
| **Corrected total** | 622.086 | 57 | | | |

*p<0.05; **p<0.01; [a] pre-test scores of the achievement test

**Table 5** shows that the pre-test scores on the two-tier diagnostic test (PRE) have a significant impact on the post-test scores of the two-tier diagnostic test (F=213.128, p < 0.01), as does the 'GROUP' (F=4.777, p < 0.05). These results show that students in the two groups are significantly different in improvement of their misconceptions about 'Weather and Climate.' The LSD post hoc test shows that students in the experiment group, who take the personalized Web-based dynamic assessment, exhibit significantly better effectiveness on the improvement of their misconceptions compared with the students in the control group who take the non-personalized Web-based dynamic assessment.

## CONCLUDING REMARKS

This research adopts Web-based dynamic assessment to perform remedial teaching on the topic of 'Weather and Climate' for junior high school students. After conventional teaching, remedial teaching is performed by leveraging GPAM-WATA to administer Web-based dynamic assessment. The dynamic assessment items included in GPAM-WATA are named 'instructional items (IIs)' because they carry instructional messages. Each item comes with three prompts, guiding learners to think and providing them more learning opportunities. Therefore, the three prompts are named 'instructional prompts (IPs)'. This research finds that learners learn more and have better learning effectiveness by answering instructional items and receiving instructional prompts in GPAM-WATA. This research further adopts the personalized dynamic assessment mechanism in GPAM-WATA. This means that GPAM-WATA identifies the concepts learners need to enhance learning based on their performance in the two-tier diagnostic test and automatically assembles dynamic assessment items based on the concepts. In this way, learners need only focus on answering dynamic assessment items related to the concepts they need to enhance their understanding. Research results show that personalized dynamic assessment allows learners to have significant better effectiveness in learning achievement and improvement of their misconceptions on the topic of'Weather and Climate'. The research findings can be explained by Wang (2010; 2011). Wang (2010) observed that Web-based dynamic assessment is effective in facilitating student learning. Through the assessment process going from pre-test, intermediate (teaching) to post-test, assessment and teaching are integrated. All the prompts, assistance, and encouragement act as a 'scaffold' that learners can climb to improve their own performance. Wang (2011) further stated that Web-based dynamic assessment can be used to perform effective remedial teaching for students. Therefore, with the help of Web-based dynamic assessment, students can obtain proper instructional prompts and have more learning opportunities.

Based on the research findings, this research suggests that Web-based dynamic assessment in GPAM-WATA should be applied to the remedial teaching of earth sciences. As for the prompt design of dynamic assessment items, the design of this research can also serve as reference to achieve better effectiveness in facilitating student learning. This research also suggests that when Web-based dynamic assessment is used for remedial teaching, personalized dynamic assessment should be administered to enable the remedial teaching to be more effective through proper use of personalized dynamic assessment mechanism and the graduated guidance by instructional prompts. Because of the limitation in time and resources, only 7$^{th}$ grader from two classes in a local junior high school were chosen as the participants, and assessment contents are limited to the topic of 'Weather and Climate.' This makes it not fully possible to infer research results to other regions, grades, and teaching materials. It is suggested that further studies should include schools in different regions, grades, and subject fields.

Moreover, it is suggested that digital teaching materials and the personalized mechanism of two-tier diagnostic assessment and dynamic assessment should be integrated and used to construct a Web-based remedial teaching mechanism for earth science education. It is also suggested that an effective strategy to actively recommend personalized digital teaching materials for inclusion in the mechanism (e.g. Wang, 2014) should be designed and implemented. The strategy is important because if personalized digital teaching materials can be provided for the scientific concepts which are more difficult to understand in addition to answering instructional items and getting instructional prompts, learners should be able to have more learning opportunities by reading the personalized recommended digital teaching materials. Students are allowed to select the contents they need to study based on their own reading pace and understanding level, which not only helps them re-organize and clarify concepts, but also enhances their learning interest and effectiveness.

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