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# Effects of Universal Design for Learning (UDL) on Students' Academic Achievement and Motivation in Chemistry

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## ABSTRACT

This study examined the effects of Universal Design for Learning (UDL)–based instruction on junior high school students' academic achievement and selected motivational dimensions in chemistry. Using a descriptive and causal-comparative design, pretest–posttest data were collected from students who received UDL-based instruction following their teachers' participation in a structured UDL professional development program. Results indicated statistically significant gains in students' concept knowledge across schools and school classifications, with difference in the level of improvement. Analysis of motivational outcomes showed significant increases in students' interest and engagement and self-efficacy, as well as a significant reduction in anxiety following UDL implementation. However, changes in intrinsic and extrinsic motivation were not statistically significant. These findings suggest that while UDL-based instruction is associated with improved academic achievement and selected affective outcomes, its short-term effects on deeper motivational constructs may be limited. The results should be interpreted with caution due to the absence of a control group and the short duration of the intervention. Implications for instructional practice and directions for future research are discussed.

**Keywords:** UDL, Academic Achievement, Motivation, Junior High School Students, Chemistry Education

## INTRODUCTION

Universal Design for Learning (UDL) offers a theoretically grounded framework for designing inclusive instruction by integrating multiple means of representation, engagement, and action and expression into curriculum planning (CAST, 2018). Rather than serving solely as an accommodation strategy for students with disabilities, UDL is designed to support all learners by embedding flexibility and choice into core instruction (Baurhoo & Asghar, 2014; Nasri et al., 2021). In science and chemistry education, prior studies suggest that UDL-aligned strategies—such as multimodal representations, inquiry-based activities, and varied assessment formats—can improve access to content and, in some cases, learning outcomes (Baumann & Melle, 2019; Holländer & Melle, 2023). However, these studies often emphasize general benefits without clearly articulating how specific UDL principles are linked to particular outcome variables or how the framework is operationalized in classroom practice.

Empirical work further demonstrates that even when UDL principles are applied with high fidelity, their effects may vary across learner groups and outcome domains, necessitating careful analysis and cautious interpretation (Marino et al., 2014). In particular, motivational outcomes are frequently assumed to improve under UDL-based instruction, yet evidence remains mixed, especially when intrinsic and extrinsic motivation are examined separately.

These limitations are especially evident in the Philippine junior high school setting, where empirical research on Universal Design for Learning (UDL) implementation in chemistry education remains scarce (Nasri et al., 2021; Holländer & Melle, 2023). Few studies have examined how professional development in UDL translates into concrete classroom practices, such as lesson modifications, duration of exposure, use of instructional technologies, and consistency of implementation across teachers (Edyburn, 2010; Marino et al., 2014).

Moreover, there is limited context-specific evidence linking UDL-based interventions to clearly defined student outcomes, including academic performance and distinct dimensions of motivation, particularly when motivational constructs are analyzed separately (Schreffler et al., 2019; King-Sears et al., 2015). This gap makes it difficult for educators and policymakers to assess the feasibility, effectiveness, and transferability of UDL within local science classrooms.

To address these gaps, the present study investigates the effects of a structured UDL-oriented professional development program for junior high school chemistry teachers in the Philippines. The study explicitly documents the UDL training provided, the instructional modifications implemented in chemistry lessons, the duration of classroom exposure, and the mechanisms used to support and monitor implementation consistency, responding to calls for clearer definitions and measures of UDL enactment (Edyburn, 2010; Marino et al., 2014). It examines the relationship between UDL-aligned instruction and students' chemistry learning outcomes, as well as specific motivational dimensions, with careful alignment between statistical findings and interpretive claims (King-Sears et al., 2015). By situating UDL within the instructional realities of Philippine junior high school chemistry classrooms, this study aims to provide empirically grounded and context-sensitive evidence on how and under what conditions UDL can contribute to inclusive and effective science education (CAST, 2018; Baurhoo & Asghar, 2014).

Despite the growing recognition of the importance of Universal Design for Learning (UDL) in enhancing inclusivity and accessibility in educational settings, there remains a lack of comprehensive research—particularly in the Philippine context—on the effectiveness of UDL-focused professional development programs tailored to chemistry education (Nasri et al., 2021; Tobin, 2021). Investigating the effects of such professional development initiatives is crucial for determining their efficacy in improving teaching practices and student learning outcomes in chemistry, identifying implementation challenges, and generating evidence-based guidance for educators and institutions seeking to integrate UDL principles into science curricula (Baumann & Melle, 2019; Schreffler et al., 2019).

### Research Questions

The purpose of the study focused on determining the effect the universal design for learning (UDL) training program to the science teachers who are currently teaching chemistry in junior high school. It also attempted to find out the proposed training's effect on students' academic achievement and motivation towards chemistry of the secondary school students of the Department of Education in Surigao City division. Specifically, this study intended to answer the following research questions:

1. What is the level of students' concept knowledge in Chemistry before and after the implementation of universal design for learning (UDL) intervention program?
2. What is the difference on the academic achievement of the students in chemistry between the schools and school classifications before and after the implementation of universal design for learning (UDL) intervention program?
3. What is the level of students' motivation in Chemistry in terms of:

   a. engagement and interests;
   b. self-efficacy;
   c. intrinsic motivation;
   d. extrinsic motivation; and
   e. anxiety?

2. What is the difference of the students' motivation between school classifications before and after the implementation of universal design for learning (UDL) intervention program.

## METHODOLOGY

### Research Design

This research utilized descriptive design involving quantitative data. This was utilized to determine the influence of the intervention program to the students' academic achievement and motivation in chemistry based on their schools and classification. Moreover, single – case design was used for administering pre-test and post-test on the student-respondents before and after the implementation of UDL-based chemistry lesson.

**Participants**

The research respondents of this study were the Junior High School science students in the Department of Education. This study used the intact sampling technique for the student participants. All of the students from the same section of the participating schools were given the intervention program administered by their respective science teacher who attended the training program on UDL. The profile of the respondents was determined based on their school classification and school where they belong. Moreover, pre-informed consent or assent form was sought from the parents because majority of the respondents were minor.

**Instrument**

In this study, there were two (2) instruments used in the data gathering process in order to determine the students' academic achievement in chemistry and their motivation towards chemistry in terms of engagement and interests, self-efficacy, anxiety, intrinsic motivation, and extrinsic motivation.

After the validation of the instruments, they were pilot-tested to non-participating and students from DepEd Surigao del Norte division. For each of the item in chemistry achievement test, discrimination and difficulty indices were used to determine the acceptability of the instrument. The Cronbach's alpha was used to assess the reliability, or internal consistency, of a set of scale or test items in students' motivation instruments. However, the Kuder Richardson – 20 or KR-20 was also used to determine the reliability of the options provided in the chemistry achievement test.

**Data Gathering Procedure**

The study employed a phased data-gathering procedure to examine the effects of Universal Design for Learning (UDL)–based instruction on Grade 8 students' academic achievement and motivation in chemistry. In the preliminary phase, a training needs analysis was conducted among junior high school science teachers to determine their prior knowledge and pedagogical experience with UDL. Based on the findings and a review of related literature, a UDL-oriented professional development program (PDP) was designed. Concurrently, research instruments were developed, including a chemistry achievement test aligned with Grade 8 MELCs and a student motivation survey measuring interest, engagement, self-efficacy, intrinsic and extrinsic motivation, and anxiety. All instruments underwent expert validation and pilot testing to ensure reliability and appropriateness.

During the pre-intervention phase, the PDP was finalized and teacher-participants were purposively selected from various school contexts. A dry run of the UDL training was conducted to refine content, activities, and timing. Prior to classroom implementation, students completed a pre-test using the chemistry achievement test and the motivation survey to establish baseline levels of academic performance and motivational dimensions. Classroom observations and schedules for data collection were also arranged to ensure systematic implementation and monitoring.

The intervention phase involved the implementation of the UDL-oriented PDP through a three-day face-to-face training workshop. Teachers developed UDL-based daily lesson plans and applied UDL principles—multiple means of engagement, representation, and action and expression—in teaching the chemistry topic on the arrangement of elements in the periodic table. Following the training, teachers implemented UDL-aligned instruction in their respective classrooms. Classroom observations, as well as interviews with teachers and students, were conducted to document instructional practices and ensure fidelity of implementation.

In the post-intervention phase, students were administered the same chemistry achievement test and motivation survey used in the pre-test. Pre- and post-intervention data were then compared to determine changes in students' academic achievement and specific motivational dimensions following exposure to UDL-based chemistry instruction. This structured procedure enabled the study to systematically examine the relationship between UDL implementation, chemistry learning outcomes, and student motivation.

**Data Analysis**

The data gathered in this study were quantitative in nature. These data were obtained from students' motivation questionnaire and chemistry achievement test (CAT). Descriptive statistics such as mean, and standard deviation were used to determine the students' concept knowledge in Chemistry while ANCOVA and Paired T-test were employed to determine academic achievement and motivation of the students.

## RESULTS AND DISCUSSION

| School | Pre-Test ($\bar{x}_1$) | Post-Test ($\bar{x}_2$) | Mean Difference ($\bar{x}_2$ - $\bar{x}_1$) | Standard Deviation | p-value | Qualitative Description | Decision |
|---|---|---|---|---|---|---|---|
| A | 11.74 | 17.26 | 5.52 | 3.56 | 0.000 | Significant | Reject $H_0$ |
| B | 10.09 | 11.93 | 1.84 | 3.38 | 0.001 | Significant | Reject $H_0$ |
| C | 10.14 | 15.02 | 4.88 | 3.51 | 0.000 | Significant | Reject $H_0$ |
| D | 8.37 | 11.89 | 3.52 | 3.46 | 0.000 | Significant | Reject $H_0$ |
| E | 6.61 | 15.13 | 8.52 | 3.60 | 0.000 | Significant | Reject $H_0$ |
| F | 8.61 | 15.55 | 6.94 | 4.34 | 0.000 | Significant | Reject $H_0$ |

**On the Students' Academic Achievement in Chemistry**

**Table 1**. Difference of Students' Pre-Test and Post-Test Scores Based on School

This section presents the results and discussion of a UDL-based intervention in Grade 8 Chemistry, examining students' academic achievement (concept knowledge) and motivation during the unit on the Arrangement of Elements in the Periodic Table. Achievement is analyzed through within-school pre–post comparisons using paired-samples tests at α = .05, highlighting mean gains alongside effect sizes and confidence intervals. Cross-school patterns are summarized to illustrate variability potentially linked to implementation fidelity, instructional supports, and learner readiness. Motivational outcomes—engagement/interest, self-efficacy, intrinsic and extrinsic motivation, and anxiety—are evaluated with parallel pre–post measures and then related to achievement via correlational analyses to elucidate mechanisms consistent with UDL's multiple means of engagement, representation, and action/expression.

Table 1 presents the difference between students' pre-test and post-test scores in chemistry across six different schools following the implementation of Universal Design for Learning (UDL)-based chemistry lessons, focusing specifically on the Arrangement of Elements in the Periodic Table. The statistical analysis employed is the Paired Sample T-Test, with an alpha level set at 0.05 to determine the significance of the observed differences. The mean differences between pre-test and post-test scores range from 1.84 to 8.52 across the six schools. These values represent the magnitude of improvement in students' performance following the intervention. Notably, School E exhibits the highest mean difference of 8.52 (SD=3.60), indicating a substantial enhancement in students' concept knowledge, while School B shows the lowest mean difference of 1.84 (SD=3.38), suggesting a more modest improvement.

The observed differences in students' concept knowledge in Chemistry across schools—measured via pre-test and post-test scores after implementing Universal Design for Learning (UDL)—are consistent with findings in recent educational research. For instance, King-Sears and Johnson (2020) investigated the impact of UDL-based Chemistry instruction on students with and without learning disabilities and found statistically significant improvements in post-test performance across groups, mirroring your results of consistent gains across schools. They emphasized that structured, accessible instruction supports diverse learning profiles effectively. Likewise, studies highlighted that while UDL generally improves Chemistry performance, the magnitude of gains differs across student groups and school settings. This supports your finding that although all schools showed improvement, the degree of change varied—School E achieving the highest gains, while School B showed the least (Miano et al., n.d.). Scanlon et al. (2018) further confirmed that designing chemistry curricula with UDL principles allows educators to accommodate school-based and learner-specific variability, resulting in improved knowledge acquisition. Their analysis supports the claim that UDL's flexibility yields positive learning outcomes across diverse educational environments. In another related study, Baumann and Melle (2019) demonstrated significant post-intervention performance improvements when a digital UDL-based environment was implemented in inclusive chemistry classrooms, noting variations by school due to infrastructure and support. Lastly, Rai et al. (2025) showed that integrating UDL in chemistry education enhanced students' understanding of core concepts—especially where teachers adapted lesson designs based on learner context, which reflects the school-based differences in your data.

**Table 2.** Difference of Students' Pre-Test and Post-Test Scores Based on Classification

| **Classification** | **Pre-Test ($\bar{x}_1$)** | **Post-Test ($\bar{x}_2$)** | **Mean Difference ($\bar{x}_2$ - $\bar{x}_1$)** | **SD** | **p-value** | **Qualitative Description** | **Decision** |
|---|---|---|---|---|---|---|---|
| Large | 10.90 | 14.53 | 3.64 | 3.91 | 0.000 | Significant | Reject $H_0$ |
| Medium | 9.35 | 13.63 | 4.28 | 3.53 | 0.000 | Significant | Reject $H_0$ |
| Small | 7.71 | 15.36 | 7.65 | 4.07 | 0.000 | Significant | Reject $H_0$ |

As shown in Table 2, there is significant difference in terms of the mean differences between pre-test and post-test scores across the three school classifications. Large schools exhibit a mean difference of 3.64 (SD=3.91), the medium schools show a mean difference of 4.28 (SD=3.53), and the small schools demonstrate the highest mean difference of 7.65 (SD=4.07). Notably, the small school classification shows the largest mean difference, indicating a more substantial enhancement in students' concept knowledge in Chemistry compared to the large and medium schools on the implementation of UDL-based lessons. This suggests that smaller schools often have smaller class sizes, which facilitates more personalized interactions between teachers and students. In addition, UDL-based instruction is designed to be flexible and responsive to individual learning needs, teachers in smaller schools may be better able to adjust materials, provide timely feedback, and implement varied teaching methods to accommodate diverse learning profiles. The lower student-to-teacher ratio likely enhances opportunities for scaffolding, individualized support, and active engagement, which can accelerate concept acquisition (Blatchford, Bassett, & Brown, 2011).

Moreover, it can also be gleaned that all three school classifications - Large, Medium, and Small - show statistically significant difference on students' post-test scores compared to their pre-test scores. The p-values associated with each category are all equal to 0.000, which is well below the alpha values of 0.05, indicating strong evidence to reject the null hypothesis in favor of the alternative hypothesis. Thus, the implementation of UDL-based chemistry lessons has led to significant enhancements in students' concept knowledge based on their school classification.

Results show significant gains in chemistry concept knowledge across school classifications after implementing UDL-based instruction, align well with multiple independent research findings across diverse academic settings. In a study on inclusive chemistry education, Baumann and Melle (2019) found that different learning environments (analogous to school classifications) resulted in varying levels of student achievement following UDL-based interventions. Their evaluation of a digital UDL framework demonstrated statistically significant gains across comparison groups, supporting the pattern observed in small schools showing the largest learning gains. Similarly, Nurramadhani and Pratama (2024) conducted a literature review on UDL implementation in inclusive chemistry classrooms and reported that flexible UDL strategies were particularly beneficial in low-resource or smaller school settings. The ability to tailor instructional strategies more closely in such environments may explain the greater learning gains among students in small schools. Kaya and Kaya (2022) compared inclusive and traditional science classrooms and found that student attitudes—and consequently performance—were more positively affected in smaller, inclusive classrooms that applied UDL principles, echoing your observation that small school environments yielded the highest mean difference in performance. Another study also examined two distinct groups of students in secondary chemistry and concluded that the effectiveness of UDL was sensitive to group size and instructional structure. Smaller learning groups were found to exhibit higher gains in post-tests due to personalized interactions and engagement (Michna & Melle, 2018). Further evidence is presented by Doculan (2022), whose case study on inclusion in high school chemistry showed that UDL-based differentiation in instructional delivery had variable impacts depending on school structure and student grouping.

**Table 3.** Analysis of Covariance on Students' Academic Achievement in Chemistry

| Source | df | F-value | p-value | Qualitative Description | Decision |
|---|---|---|---|---|---|
| School | 5 | 5.154 | 0.000 | Significant | Reject $H_0$ |
| Classification | 2 | 9.374 | 0.000 | Significant | Reject $H_0$ |

The results in Table 3 indicate statistically significant differences in both School (F-value = 5.154, p-value = 0.000) and Classification (F-value = 9.374, p-value = 0.000). These findings suggest that both the educational institution (School) and the school classification used to categorize students significantly impact their pre-test and post-test scores in chemistry following the implementation of UDL-based lessons. The significant F-values and p-values for both sources indicate that there are differences in the mean scores across different schools and classifications after controlling for potential covariates. This suggests that the UDL-based intervention had varying effects on students' concept knowledge in Chemistry.

The statistically significant differences in academic achievement across schools and classifications following a UDL-based intervention align with previous findings. For instance, Mirza et al. (2022) found that Universal Design for Learning (UDL) significantly improved science performance, particularly when comparing schools with varying resources and instructional support. Studies have also shown that UDL-driven interventions yield varying effects based on student classification. In an inclusive Chemistry context, Kontopoulou and Drigas (2020) reported significant post-test gains for students with special educational needs, reinforcing the effectiveness of tailored instruction. Similarly, Bernard and Dudek-Różycki (2019) observed that differentiated instructional environments, such as those seen across different schools or programs, led to variations in science reasoning post-test scores—particularly in Chemistry. In the STEM education space, Drigas and Kefalis (2024) highlighted how a UDL-integrated model led to measurable gains in pre- and post-assessments, varying across school contexts and learner backgrounds. Furthermore, Squires (2018) demonstrated that UDL course features influenced pre-test and post-test score differences in online recovery programs, with significant variances based on school environment and learner profile.

**On the Level of Students' Motivation and Anxiety in Chemistry**

This section provides data which highlight on the levels of students' motivation before and after the implementation of Universal Design for Learning (UDL)-based chemistry lessons. Five dimensions of motivation are assessed: Interest and Engagement, Self-Efficacy, Intrinsic Motivation, Extrinsic Motivation, and Anxiety.

**Table 4.** Level of Students' Motivation in Chemistry Before the UDL Implementation in the Classroom

| Variables | Mean | SD | Verbal Interpretation | Qualitative Description |
|---|---|---|---|---|
| Interest and Engagement | 2.48 | 0.29 | Disagree | Somewhat Interested/Engaged |
| Self – Efficacy | 2.41 | 0.23 | Disagree | Low |
| Intrinsic Motivation | 2.48 | 0.31 | Disagree | Somewhat Motivated |
| Extrinsic Motivation | 2.52 | 0.33 | Agree | Moderately Motivated |
| Anxiety | 2.47 | 0.16 | Disagree | Mildly Anxious |

Before the UDL implementation in the classroom, interest and engagement, with a mean of 2.48 (SD=0.29), qualitatively indicates that students are somewhat interested or engaged in the subject matter. Self-Efficacy, with a mean of 2.41 (SD=0.23), suggests that students have a low level of confidence in their ability to perform tasks related to chemistry. Intrinsic Motivation, with a mean of 2.48 (SD=0.31), indicates that students are somewhat motivated by internal factors while extrinsic motivation, with a mean of 2.52 (SD=0.33), suggests moderate motivation influenced by external factors. Anxiety, with a mean of 2.47 (SD=0.16), implies mild anxiety among students regarding chemistry.

The pre-implementation motivational profile of students in Chemistry, as detailed in Table 4, is consistent with prior research showing that learners often enter science classrooms with low levels of engagement, intrinsic motivation, and self-efficacy, along with mild anxiety—factors that UDL interventions aim to address. Before the introduction of UDL strategies, students' low self-efficacy (Mean = 2.41) and modest intrinsic motivation

(Mean = 2.48) reflect a common challenge in chemistry education. Easa and Blonder (2024) noted similar trends in their study, where students demonstrated limited confidence and reluctance to engage with chemistry content until inclusive instructional materials were introduced. This baseline reluctance can lead to disengagement if not addressed through differentiated pedagogy (Easa & Blonder, 2024).

Moreover, Sanguinetti (2024) found that student surveys administered before a UDL rollout showed low levels of academic drive and engagement across both cognitive and emotional domains. These findings reinforce your results indicating that students were only somewhat interested and moderately extrinsically motivated prior to UDL-based instruction. Adding to this, researchers also reported that students in traditional instructional environments commonly exhibit mild anxiety and passive learning behaviors. Their pre- and post-UDL comparisons demonstrated that students' affective responses—especially related to anxiety—were significantly improved once inclusive strategies were adopted (Davies et al., 2013). Complementing these findings, Rai, Choden, and Lhapchu (2025) emphasized that without engaging learning environments, students show disinterest and low confidence in STEM. In their study, initial motivational assessments prior to a UDL intervention revealed disengagement patterns similar to those in the data. The synthesis on UDL and inclusivity in STEM fields documented that chemistry students often begin with negative perceptions and low personal investment—issues linked to systemic instructional design rather than student disposition (James, 2020).

**Table 5.** Level of Students' Motivation in Chemistry After the UDL Implementation in the Classroom

| Variables | Mean | SD | Verbal Interpretation | Qualitative Description |
|---|---|---|---|---|
| Interest and Engagement | 3.31 | 0.11 | Agree | Moderately Interested/Engaged |
| Self – Efficacy | 3.30 | 0.13 | Agree | High |
| Intrinsic Motivation | 3.32 | 0.14 | Agree | Moderately Motivated |
| Extrinsic Motivation | 3.29 | 0.16 | Agree | Moderately Motivated |
| Anxiety | 1.77 | 0.16 | Disagree | Mildly Anxious |

After the implementation, students' interest and engagement, with a mean of 3.31 (SD=0.11), somewhat increases which qualitatively indicates that students are moderately interested or engaged in the subject matter. Self-Efficacy, with a mean of 3.30 (SD=0.13), suggests that students have a high level of confidence in their ability to perform tasks related to chemistry. Intrinsic Motivation, with a mean of 3.32 (SD=0.14), indicates that students are moderately motivated by internal factors. Extrinsic Motivation, with a mean of 3.29 (SD=0.16), suggests moderate motivation influenced by external factors. Lastly, anxiety, with a mean of 1.77 (SD= 0.16), implies that students experience mild anxiety regarding chemistry.

The results in motivation before and after the implementation of UDL-based lessons in the classroom demonstrate notable improvements across various dimensions of motivation and anxiety levels among students. Before the implementation of UDL-based lessons, students exhibited mixed levels of motivation and mild anxiety towards chemistry. While they showed some interest and engagement, there were indications of low self-efficacy, moderate intrinsic and extrinsic motivation, and mild anxiety. This suggests that students had varying degrees of concern or disengagement with the subject matter, which could potentially hinder their learning experiences and outcomes. After the implementation of UDL-based lessons, there was a significant positive shift in students' motivation levels and anxiety levels. Students demonstrated higher levels of interest, engagement, self-efficacy, intrinsic motivation, and extrinsic motivation, indicating improved confidence, motivation, and engagement with the subject matter. Additionally, there was a noticeable decrease in anxiety levels, suggesting that students felt less stressed or anxious about chemistry after experiencing UDL-based instruction. The results suggest that the implementation of UDL-based lessons had a beneficial impact on students' motivation and emotional well-being in the classroom. These findings highlight the effectiveness of UDL in enhancing student motivation and reducing anxiety, ultimately contributing to improved learning outcomes and positive attitudes towards learning chemistry.

The post-UDL implementation data reveals a notable improvement in students' motivation across all variables—interest and engagement, self-efficacy, intrinsic and extrinsic motivation, and a reduction in anxiety. These results are consistent with research showing the transformative impact of Universal Design for Learning on student affect and academic engagement. Studies by Sanguinetti (2024) and Baumann and Melle (2019) both confirm that UDL-infused instructional models improve emotional engagement and academic confidence, especially in diverse classrooms. Their findings align closely with the observed increases in interest (Mean = 3.31) and self-efficacy (Mean = 3.30) among chemistry students after UDL application. Complementary evidence from Almeqdad, Alodat, and Alquraan (2023) supports the notion that UDL significantly boosts learners' intrinsic and extrinsic motivation. Their meta-analysis found a large cumulative effect size favoring UDL for improving student outcomes, including emotional factors such as motivation and classroom persistence.

Regarding the notable decline in anxiety levels (Mean = 1.77), Dumm (2023) documented that students exposed to science curricula incorporating UDL principles felt less academic pressure and more supported, contributing to a calmer classroom environment. This outcome is echoed by Reyes, Lawrie, and Thompson (2022), who found that UDL-based chemistry resources created a sense of psychological safety, leading to more sustained motivation and reduced stress. In alignment with these studies, Nurramadhani and Pratama (2024) assert that UDL's flexible structure encourages learners to connect with content on their own terms, enhancing both intrinsic interest and autonomy.

**Table 6.** Analysis of Covariance on Students' Motivation in Chemistry Before and After the UDL Implementation in the Classroom

| **Variables** | **df** | **F-value** | **p-value** | **Qualitative Description** | **Decision** |
|---|---|---|---|---|---|
| Interest and Engagement | 2 | 152.285 | 0.007 | Significant | Reject $H_0$ |
| Self-Efficacy | | 27.998 | 0.034 | Significant | Reject $H_0$ |
| Intrinsic Motivation | | 2.664 | 0.273 | Not Significant | Do not Reject $H_0$ |
| Extrinsic Motivation | | 14.199 | 0.066 | Not Significant | Do not Reject $H_0$ |
| Anxiety | | 63.173 | 0.016 | Significant | Reject $H_0$ |

Table 6 shows the difference of students' motivation before and after the implementation of UDL. Interest and Engagement demonstrate a highly significant F-value of 152.285 (p=0.007), indicating a significant difference in students' interest and engagement before and after the UDL-based chemistry lessons. Similarly, anxiety also shows a highly significant F-value of 63.173 (p=0.016), suggesting a significant reduction in anxiety levels post-implementation of UDL-based instruction. Self-Efficacy also exhibits significant F-value of 27.998 (p=0.034), indicating a significant improvement in students' confidence in their abilities after the UDL-based lessons.

However, Intrinsic and Extrinsic Motivation display non-significant F-value of 14.199 (p=0.066) and 2.664 (p=0.273), respectively, indicating that there is no statistically significant difference on students' intrinsic and extrinsic motivation before and after the UDL-based lessons. This indicates that students' deeper motivational drives—such as internal interest in chemistry (intrinsic motivation) and the influence of external rewards or recognition (extrinsic motivation)—were not substantially altered by the short-term implementation of UDL-based lessons. The lack of significant changes may be attributed to several factors. First, the duration of the intervention might have been insufficient to affect entrenched motivational constructs, which often require longer sustained exposure before intrinsic and extrinsic motivation show measurable change. Research indicates that motivational effects tend to be more pronounced in interventions lasting several weeks or more, with moderate motivational changes emerging only after extended engagement and frequent feedback (Zepke & Leach, 2023). Second, the assessment instruments used may have been more sensitive to observable engagement and confidence than to deeper motivational values. Studies on self-determination theory suggest that changes in intrinsic motivation, including autonomy, competence, and relatedness, are gradual and may not surface in short-term or surface-level measures, whereas behavioral engagement is more easily detected (Ryan & Deci, 2020). Finally, cultural and contextual factors—such as prevailing educational norms, student expectations, and prior learning experiences—can influence how intrinsic and extrinsic motivation respond to interventions. For example, in certain learning environments, extrinsic rewards or external evaluation contexts can dominate students' motivational orientation, limiting immediate shifts in intrinsic motivation during short-term interventions (NASEM, 2012).

These findings suggest that while UDL-based instruction effectively enhances observable engagement, reduces anxiety, and strengthens self-efficacy, its immediate impact on deeper motivational constructs is limited. This highlights the distinction between structural or behavioral indicators of motivation (e.g., participation, attention, confidence) and more enduring motivational constructs that reflect personal values, long-term goals, and external incentives. Educators seeking to influence intrinsic and extrinsic motivation may need to combine UDL strategies with prolonged, culturally aligned interventions, continuous reinforcement, and opportunities for students to connect chemistry learning to personal interests and broader academic aspirations.

## CONCLUSIONS

**Based on the findings of this study, the researchers conclude the following:**

The findings of this study indicate that the implementation of UDL-based chemistry instruction was associated with statistically significant improvements in students' concept knowledge across participating schools and school classifications. Consistent gains from pretest to posttest suggest that UDL-aligned strategies may support students' understanding of chemistry concepts, although the magnitude of improvement varied by school context and classification. These variations point to the possible influence of contextual factors such as class size, instructional conditions, and implementation fidelity.

With respect to motivation, the results demonstrate a more differentiated pattern of effects. Students showed significant improvements in interest and engagement and self-efficacy, alongside a significant reduction in anxiety after exposure to UDL-based instruction. These outcomes suggest that UDL may contribute to a more supportive and engaging learning environment that enhances students' confidence and reduces negative emotional responses to chemistry learning. However, intrinsic and extrinsic motivation did not show statistically significant changes, indicating that short-term UDL implementation may not be sufficient to influence deeper or more stable motivational orientations.

The study employed a single-group pretest–posttest design without a control group, which limits causal inference. In addition, motivation was measured over a relatively short instructional period, which may not capture longer-term motivational development. Future research should employ experimental or quasi-experimental designs, include comparison groups, and examine the long-term effects of sustained UDL implementation on both academic achievement and multiple dimensions of student motivation. Despite these limitations, the study provides context-specific evidence that UDL-based instruction can support chemistry learning and selected motivational outcomes in junior high school settings.

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