Instructional Interventions and Affective Beliefs as Predictors of Achievement and Retention of Learning

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Abstract - *Path and factor analyses were used in this study to investigate direct and indirect influences of instructional interventions on achievement and retention of learning among freshmen students in Mathematics as mediated by affective beliefs. The varying classroom contexts were hypothesized to influence affective beliefs through the application of varying instructional interventions – traditional teaching, radical constructivist, and social constructivist. The randomized equivalent groups pre-posttest experimental design was used to generate the needed data for analysis. Results showed that constructivist instructional approaches directly and indirectly influenced achievement measures with the indirect effects mediated by control orientation belief of students which was found to be the only one among four affective beliefs considered in this study to influence achievement measures. Social constructivist interventions did not show direct influence on retention of conceptual understanding and procedural fluency while traditional instructional intervention was not found to be a significant predictor of both affective beliefs and achievement measures.These results confirm for the most part the hypothesized relations among instructional interventions, affective beliefs, and achievement measures.*

Keywords: *Constructivism, affective beliefs, achievement, retention of learning, conceptual understanding, problem solving skills, procedural knowledge*

INTRODUCTION

As higher education institutions put premium and emphasis to outcomes of education, so too must instructional interventions in the classrooms focus on instructional outcomes. Educational practitioners typically do researches that delve so much on the outcomes of teaching approacheswhile psychologists do research on the role of affective factors on learning outcomes. Local research literature on the inter-relations among instructional interventions, affective factors, learning outcomes in terms of academic achievement and retention of learning appears to be scarce. While research has shown consistently that instructional approaches influence learning outcomes and affective factors were found to influence academic success, there is little work at looking into the dynamics of the simultaneous influences of these variables along various dimensions of learning outcomes emphasized in emerging science and mathematics education today. These are along conceptual understanding, problem solving skills, and procedural fluency.

On the other hand, while the advantages of constructivist instructional procedures beginning from the early works of cognitive psychologist, Piaget, have been heavily supported in science and mathematics education literature [1, 2, 3, 4] that drew the radical-social constructivist continuum, constructivism has been accused of being overly cognitive and dwells so much on the idea of knowledge construction [5] without consideration of personal affective beliefs of students even as an earlier suggestion of the possible interplay of cognitive and affective factors on achievement was put forward. The role of self-efficacy beliefs [6], goal structures [7, 8], control orientation and interest and value beliefs [9] have been identified as personal affective factors that might mediate the influences of instructional approaches on the outcomes of learning. Oyerman and Packer [10] argued that classrooms are socially situated in certain context providing the setting within which learning is processed. Thus psychological affective factors may probably feed into the intensity of students'

engagements in learning activities mediating academic achievement measures.

Instruction therefore must be informed by how particular instructional interventions impact on affective beliefs, achievement measures, and retention of learning by students in order to provide teachers guidance in their choice of instructional design they need to employ in their teaching practice. The researcher believes that understanding how the interplay of affective factors and constructivist instructional interventions may impact achievement and retention of learning, and thus enabling teachers to mobilize a truly hands-hearts-minds approach to instruction.

Results of this study would be most significant to educational practitioners as teachers, administrators and researchers. Teachers will be provided with empirical bases in shaping and managing the interplay between classroom context as shaped by instructional intervention and affective factors to improve learning outcomes. Of special interest would be the contribution of this study to the continuing debate about radical and social constructivism in science and mathematics education. Administrators stand to gain guidance in the formulation of evaluative criteria for the evaluation of teaching effectiveness in classroom instruction as constructivism presents what could be said as the final challenge to traditional and contemporary instruction. It will also contribute to theory and opens to other researchers the multi-dimensionality of the classroom context as it is shaped by instructional interventions as an area of productive research, especially in science and mathematics education.

Experiment data from 92 freshmen students randomly selected from among 347 students enrolled in basic mathematics courses were used in the study. They were randomly assigned to three experimental groups. While results of this study may have limited generalizability to other populations typical of experimental results in the social sciences, it presents novel and original findings on the relationships among the variables studied.

OBJECTIVES OF THE STUDY

The objective of this study is to investigate the interrelationships among four variables: instructional interventions, affective beliefs, achievement, and retention of learning. Specifically it aims to answer the following specific research questions:

1. Which of the following factors are predictors of affective beliefs, achievement and retention of learning?
   a. Traditional instructional intervention
   b. Radical constructivist instructional intervention
   c. Social constructivist instructional intervention
2. Which of the following factors are predictors of achievement and retention of learning?
   a. Goal Orientation
   b. Control Orientation
   c. Self-efficacy
   d. Interest and Value
   e. Achievement measures

METHODS

The inter-relationships among three major variables – classroom contexts as shaped by instructional interventions, affective beliefs that are believed to promote learning engagements of students, and learning outcomes consisting of both immediate achievement and retention of learning formed the framework of this study. Instructional interventions consisted of three procedures – the traditional lecture-recitation, the radical constructivist, and the social constructivist approaches.

The relationships indicated in the framework are well supported in literature.Instructional interventions are believed to shape the social context of the learnersduring the teaching and learning process and have been suggested to influence learning through their effects on cognition and conceptual change [9, 11]. These classroom contexts were also found to influence thinking and affect [12]. Varying instructional arrangements necessarily create varying learning environments[13]; effect varying classroom organization, interactionand the nature of strategic engagements of students in learning [14, 15, 16] and impact on the development of knowledge domains and enhance learning among students [17].

Constructivist teaching approaches have consistently shown its superiority over traditional teaching arrangements. A number of researchessupported this observation at varying degrees and in varied situations and contexts. The works of Kim [18], Doolittle [19], Heylighen [20], Yager[21], and Schoenfeld[22] are some of the examples that showed strong support to the above observation. The most recent and seemingly stronger support to the promise of constructivism on

achievement is provided by Lunenburg [23]. In his concluding statement, after arguing for constructivism and critical thinking, he stated:

> *"Critical thinking and constructivism offer real promise for improving the achievement of all students in the core subject areas".*

On the other hand, personal affective beliefs have been identified and found to be active mediators of learning especially in enhancing their classroom engagements. Control orientation [24], a form of affective beliefdetermines the individual learner's belief about their control over outcomes of learning. The meditational character of control is supported by Weiner [25] who viewed control over outcomes in terms of its locus being either internal (stable and controllable) or external (unstable and beyond the control of the individual) and thus influences the quality of engagement in learning activities. Ormrod [26] claimed that students with internal locus of control have greater positive control over outcomes of schooling. They are the individuals who will tend to exert more effort and persist despite difficulties on learning activities. Externally controlled individuals on the other hand tend to give up on task quite easily, get frustrated easily, and attribute success and failure to external and uncontrollable sources.

The second affective belief considered in this study is self-efficacy.It is a self-concept or self-referent belief of individuals focused on judgment about how well an individual can execute courses of actions when faced with a particular situation[27], [6]. It is posited that beliefs about one's abilities are better predictors of performance rather than the abilities themselves. In a meta-analytic analysis of 36 studies, efficacy about specific tasks was found to be a strong predictor of academic performance [28].

Goal orientation belief is another self-referent belief and is about the goals that individuals refer to in order to determine choice of actions that they take in a sustained and directed manner. Ames [29] holds that goals spark actions and influence the extent to which these actions are directed and sustained. Goals activate alternative patterns of beliefs, attributions, and affect to produce the intentions of behavior. Goals are directed towards either mastery (learning) or performance (ego) orientations. Students with mastery goal orientation find learning activities interesting and tend to focus and stay on task better than those with ego or performance goal orientation [26], [30], [29], [31]. The foregoing literature suggest that specific goal orientation leads to the employment of specific learning strategies, effect specific level of engagements on learning tasks and consequently influences levels of achievement.

On the other hand, works that link interest and value belief with respect to classroom context and achievement abound. Interest and value belief refer to the general attitude or preference to a content, tasks, objects, and learning activities including their assignment of the degree of usefulness and importance (value). Hidi [32] differentiates between the stable interest and situational interest which he claims to be easily influenced by contexts and the learning environment. In reviewing a number of research conducted on interest and value beliefs, she concluded that bothsituational and stable interest influence cognitive performance. Students who find objects, tasks, activities as either interesting or important have superior comprehension and recall of learned materials [33] will engage, reengage, and persevere in subject related activities [34]; affects attention, memory, and representation of possibilities [35, 36, 37]; and produce qualitative differences in learning [38].Asher [39], Asher and Markell[40] have all found that interest on learning materials effected superior comprehension and recall among students.

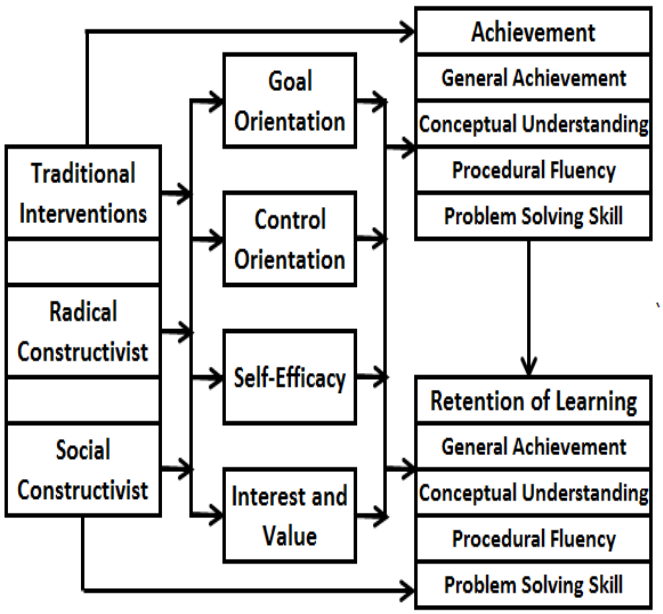

Figure 1. The Conceptual Framework

The foregoing discussions lead us to the work of Pintrich, Marx, and Boyle[9] who posited that the foregoing affective factors have strong potentials to influencing learning and achievement even as these affective factors are not stable and are readily influenced by instructional contexts. On the basis of these literatures the following conceptual framework (Figure 1) guided the design and conduct of an experiment to test and verify the following hypotheses.

Research Hypotheses

With the foregoing conceptual framework that binds this study, the following research hypotheses were drawn and tested.

a) Instructional interventions with the exception of the traditional lecture-recitation approach are significant predictors of both personal affective beliefs and achievement as well as retention of learning;
b) At least one of the four affective beliefs are significant predictors of achievement and achievement retention of learning; and
c) Achievement measures are significant predictors of retention of learning.

The Research Design

The Randomized Parallel Groups Pre and Posttest Design of true experimental procedure was used in this study. Ninety-six freshmen mathematics students were randomly selected from among 347 students enrolled in beginning college mathematics course in a university. These students were randomly assigned to three experimental groups – The Traditional Lecture-Recitation group (the control group); the Radical Constructivist group and the Social Constructivist groups comprised the treatment groups. The design is illustrated in Figure 2 where R represents random assignment to groups,O represents observations, X represents treatments. The odd observations represent pretest measures while even observations are the posttest measures.

$$R \rightarrow \begin{matrix} G_1 & O_1 & X_1 & O_2 \\ G_2 & O_3 & X_2 & O_4 \\ G_3 & O_5 & X_3 & O_6 \end{matrix}$$

Figure 2. The Experimental Design

The radical constructivist group of students was exposed to highly individualized instructional interventions while the social constructivist group received instructional interventions that required them to work in groups of five to seven students. The traditional group of students was exposed to the usual lecture and recitation format primarily led by theteacher. All the groups were supported with instructional modules. However, the instructional modules for the constructivist groups contained self-instructional prompts to guide the students as they themselves learn the materials with minimal intervention from the teacher.Moreover, teacher interventions to the constructivist groups were limited to additional prompts and directions in the form of suggestions, scaffolding questions, but never on the explanation of concepts intended to be learned.

In other words the constructivist groups worked on the assumption of constructivist theories that providing rich and guided experiences for students from where they can construct knowledge rather than direct teaching would facilitate better learning and retention of learned materials. Radical constructivist premise puts greater emphasis on the individual actions on experiences and social interaction as contributory to experience but not a precondition to effective learning. Social constructivist premise on the other hand puts premium to social interaction as a way to more meaningful provision of experiences that support learning.

Two test instruments were developed by the researcher for this study. The Basic Mathematics Achievement Test (BMAT) was designed and constructed following the generally accepted test construction procedures. The test consisted of 30 items with difficulty indices between 0.29 to 0.79; discriminating power indices between 0.38 to 0.76; and effectiveness of distracter choices of at least 6 percent. General achievement is measured by the score of students on the whole test, conceptual understanding was indicated by the scores of students determined by 23 items in the BMAT designed to measure conceptual change, and problem solving achievement was measure by the scores of students on the remaining 17 items of the BMAT. Procedural fluency was measured through the evaluation of written procedural solutions of students to four of the 17 problem solving items guided by a rubric and peer review of the rubric scoring. The test recorded a KR-20 reliability coefficient of 0.87.

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The Affective Beliefs Scale (ABS) was used to measure the affective beliefs of students along the four identified dimensions in the research framework. It was developed by the researcher following the generally accepted scale (i.e., Likert scale) development processes. Items along dimensions were developed from extensive literature and pre-tested for initial reliability of the test. The confirmatory factor analysis using principal components analysis was used to verify the dimensionality of each scale items. The final form of the ABS yielded 47scale items(15 on goal orientation; 12 on control orientation; 11 on self-efficacy; and 9 for interest and value) which loaded strongly (factor loadings of at least 0.67) onto their respective dimensions. Cronbach alpha coefficients for the dimensions ranged from 0.87 to 0.96.

Consistent with the intention of this study to looking for direct and indirect influences of instructional interventions on affective beliefs and achievement and retention of learning as well as of affective beliefs on achievement and retention of learning path analysis using series of stepwise multiple regression analysis using dummy variables for teaching approach was used in this study that provided bases for building a series of predictive models providing explanations on the causal relationships of each set of predictor variables on dependent variables.

The experiment was conducted for a period of three instructional weeks prior to the students' first major examination (the preliminary term examinations) consisting of nine hours of instruction. The BMAT was used as the preliminary term examination for the three groups which served the purposes of the posttest in this experiment. All students took pre-test prior to the conduct of the experimental treatments as bases for initial comparisons to determine possible initial differences among groups even after randomized assignment to groups. Four subjects dropped out of school leaving a total of only 92 students – 31 in the traditional group, 30 in the social constructivist group, and 31 in the radical constructivist group.

Retention of learning measures were taken 27 days after the conduct of the BMAT posttest.In like manner, except for delayed posttest, pretest and posttest scores for affective beliefs were conducted using the Affective Belief Scale. Prior to path analytic procedures, comparison of pretest results for both the BMAT and ABS were done which revealed no significant differences between groups along achievement and affective belief measures. Thus, the path analytic procedures used the posttest results for both achievement and affective belief statistical processes.

RESULTS AND DISCUSSION

Results of path analyses indicated consistency with the conceptual framework. The hypotheses forwarded were for the most part confirmed by these results. A series of regression analyses using dummy variables for teaching approach values with the traditional instructional intervention (TII) as reference group to determine influences of the independent variables against the dependent variables as suggested by the framework.

Teaching Approach as Predictors of Affective Beliefs, Achievement, and Retention of Learning

Varying instructional interventions have their own specific sets of practices and procedures that create unique classroom contexts which are built into the general classroom environment within which learners have to operate and learn. Direct and indirect predictors of the different dependent variables as suggested in the framework were sought in the following analyses.

Predictors of Achievement

Table 1 shows the results of the stepwise regression analysis performed to determine significant predictors of achievement. None of the affective beliefs entered the regression equation while radical and social constructivist instructional interventions did which meant that constructivist instructional interventions impact general achievement confirming once again the superiority of constructivist approaches against traditional instructional intervention of the lecture-recitation type.

Results showed that at least 27% of the variations in general achievement (GA) is explained by radical constructivist instructional intervention (RCII) while only 9% (but still significant) is explained by social constructivist instructional intervention (SCII) while traditional instructional intervention (TII) did not enter into the regression equation. Interestingly, only the affective factors COB and GOB were found to be significant predictors of conceptual understanding However, their explanatory power of 6.25% and 5.29%, respectively, appears to be weak.

Table 1.Regression of achievement measures on instructional interventions and affective belief

Predictors	Unstandardized coefficients		Standardized coefficients	t	Sig.
	B	Std. error	Beta		
General achievement (GA)					
Radical constructivist (RCII)	4.12	0.88	0.52	4.68	0.000
Social constructivist (SCII)	2.38	0.88	0.30	2.70	0.008
Conceptual understanding achievement (CUA)					
Goal orientation	-0.13	0.05	-0.25	-2.56	0.012
Control orientation	-0.11	0.05	-0.23	-2.26	0.026
Problem solving achievement (PSA)					
Radical constructivist	2.12	0.58	0.36	3.69	0.000
Procedural fluency achievement (PFA)					
Radical constructivist	19.88	4.50	0.50	4.41	0.000
Social constructivist	16.54	4.72	0.42	3.50	0.001
Control orientation belief (COB)	0.95	0.37	0.27	2.57	0.012

Interestingly however, the coefficients are negative which reveal that as COB leans toward ability orientation and control orientation leans toward external orientation, conceptual understanding become more effective.

This might be the result of anxiety and the level of challenge constructivist intervention may have created in the classroom environment that led them to exert greater effort and focus thereby improving their performance. That is - putting pressure on the COB and goal orientation belief (GOB) of students produces as it interplays with instruction produces net positive effects on conceptual understanding.

The results also showed that RCII entered the regression equation on problem solving skills accounting for more than 13% (R = 0.36) of the variation thereof. The two constructivist instructional interventions and control orientation belief were found to be significant predictors of procedural fluency achievement (PFA) with the RCII and SCII accounting for more than 25% (R=0.50) and 17% (R=0.42), respectively while COB explained only 7% in PFA.

The foregoing results, shows the efficacy of the RCII as an instructional approach in effecting changes on achievement measures while highlighting the inefficacy of TII. While these results showed some factors out of the regression equations in the explanation of the various dimensions of achievement, findings are still consistent with the conceptual framework and still adequately respond to the hypothesized relations among these variables.

Table 2. Regression analysis of retention measures on instructional intervention, affective belief and achievement.

Predictors	Unstandardized coefficients		Standardized coefficients	t	Sig.
	B	Std. Error	Beta		
General retention of learning (GRL)					
Radical constructivist	4.33	0.75	0.50	5.75	0.000
General achievement	0.31	0.09	0.28	3.27	0.002
Conceptual understanding retention (CUR)					
Radical constructivist	3.17	0.60	0.57	5.33	0.000
Social constructivist	1.52	0.60	0.27	2.56	0.012
Problem solving retention (PSR)					
Radical constructivist	2.74	0.44	0.54	6.26	0.000
Problem solving achievement	0.20	0.07	0.23	2.65	0.010
Procedural fluencyretention (PFR)					
Procedural fluency achievement	0.63	0.07	0.68	9.44	0.000
Radical constructivist	7.00	2.64	0.19	2.65	0.010

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Predictors of General Retention of Learning

Table 2 shows the result of the regression analysis when retention of learning is regressed on teaching approach, affective beliefs, and achievement.

Results showed that only RCII and GA significantly contributed to general retention of learning GRL)at 25% and 7%, respectively. The constructivist approaches significantly predicted conceptual understanding retention (CUR) accounting for a total of about 40% of its variations with 32.49% on RCII and 7.29% on SCII. Problem solving retention (PSR)was predicted by RCII and PSA at 29% and 5%, respectively, for a total of 34%.Finally, procedural fluency retention (PFR) is significantly influenced by procedural fluency achievement (PFA) and RCII which explains 46% and 3.81% of the variations in scores, respectively.

Interestingly, none of the affective beliefs actually contributed directly to all dimensions of retention measures with radical constructivist intervention consistently predicting significantly all dimensions of retention learning measures. Likewise, conceptual understanding achievement (CUA) did not emerge as a significant predictor of conceptual understanding retention (CUR).

While the foregoing findings did not confirm the research hypothesis on the influence of affective beliefs on retention measures, the hypothesized influence of achievement measures and instructional interventions on retention of learning is generally supported. What is consistently shown however is the efficacy of RCII in positively influencing GRL as well as in its specific measures – CUR, PFR, and PSR.

Moreover, while we have seen earlier the efficacy of SCII on some achievement measures, SCII did not directly influence its retention. It might be that SCII has indirect influence on retention through its influence in achievement. This will have to be explored using path analysis to be presented later in this article through path analytic means.

Teaching Approach as Predictor of Affective Beliefs

Table 3 shows the results of the stepwise regression analyses made for affective beliefs on instructional intervention. Results showed that none of the instructional interventions predicted the affective factors goal and efficacy beliefs. On the other hand constructivist instructional interventions accounted for a total of about 28 percent of the variation on control orientation with SCII accounting for 20.25% and the RCII explaining 7.49%. On the other hand, the RCII accounted for only 5.29% of the variation in interest and value belief (IVB). Interestingly, relationship with COB was negative further providing some kind of support to the relationship of control orientation with achievement measures earlier established.

Path Analytic Models of Predictors of Affective Beliefs, Achievement and Retention

Considering the results in the foregoing regression analyses, the following figures graphically illustrate the causal relationship between and among dependent and predictor variables with the indicated path beta weights.

General Achievement-General Retention Model

Figure 3 shows the path analytic model for general achievement and general retention of learning. Evidently, the RCII directly and positively influenced both general GA and GRL while the SCII directly and positively influenced GA. The path analytic model for GA and GRL of learning did not include affective belief factors.

Table 3.*Regression analysis of affective beliefs on instructional interventions*

Dependent variables	Predictors	Unstandardized coefficients		Standardized coefficients	t	Sig.
		B	Std. Error	Beta		
Control	Social constructivist	-4.95	1.25	-0.45	-3.97	0.000
	Radical constructivist	-3.15	1.25	-0.29	-2.52	0.013
Goal	None					
Efficacy	None					
Interest and value	Radical constructivist	2.55	1.12	0.23	2.27	0.025

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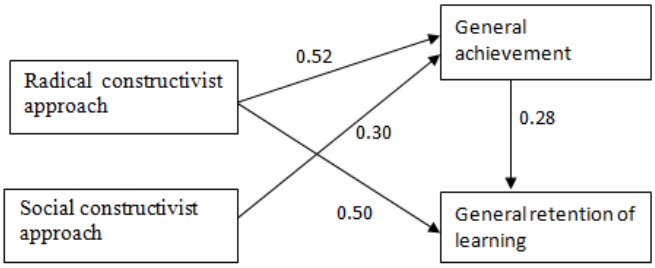

Figure 3. Predictors of General Achievement and General Retention of Learning

The model shows that RCII directly influence CUAwith path standardized Beta coefficient of 0.52exhibiting stronger influence more than that of social constructivist with path standardized Beta coefficient of only0.30.Coupled with this is the indirect influence of RCIIwith net effect of (0.52)(0.28) = 0.15 standardizedbeta coefficients on GRL for a total effect of 0.65 or 42.25% of the variation on GRL. On the other hand, SCII has only indirect influence equivalent to (0.30)(0.28) = 0.08 or 8% of the variation in GRL. Thus the two constructivist instructional interventions strongly influence GRL accounting for more than 50% of the variation in GRL – a strong and very significant influence.

Conceptual Understanding-Conceptual Retention Model

Predictors of CUA and its consequent retention is shown in Figure 4. The path analytic model shows that CUAis influenced by four factors – COB, GOB, RCII and SCII. The GOB and COB directly but negatively influences CUA with standardized Beta path weights of -0.25 and -0.23, respectively. On the other hand SCII and RCII have a net positive indirect influence on CUA through its influence on COB. SCII accounts for indirect combined net standardized Beta path weight of (- 0.45)(-0.23) = 0.10 or only about 1% of the total variation of CUA. Similarly, RCII exhibits a net indirect standardized path Beta weight of – 0.29)(– 0.23) = 0.07 or less than 0.5% of the variation of CUA. This finding appears to be counter intuitive as literature supports a positive relationship between the two. However, these findings have important implications in instructional practice – that instructional interventions must be able to create classroom contexts that constantly challenge these beliefs of students in order to effect positive changes in achievement.

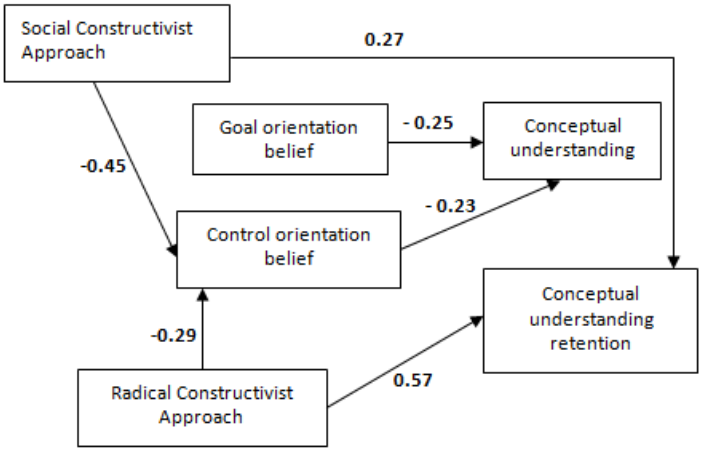

Figure 4. Predictors of conceptual understanding and its retention

The more important benefit however of SCII and RCII is their contributions to influencing retention of previously learned concepts contributing about 7.29% and 32.49% respectively of the variation in CUR. This finding meant that RCII with its highly individualized set-up with attendant help mechanism designed to engage students' deep cognitive engagement created a context where strong accountability of students over their own learning can improve retention of conceptual understanding and that such challenge have negative effects on COB producing net positive influence on CUA although such indirect influences are minimal.

Problem Solving and Problem Solving Retention Model

The path analytic model for problem solving skills shows straightforward causal relationships (Figure5). Among the instructional interventions, only the RCII was found to have direct effect on problem solving achievement (PSA) and problem solving retention (PSR) which was not at all mediated by affective beliefs. Problem solving skill achievement was similarly found to have direct effect on retention of problem solving skill with Beta path weight of 0.23. This model indicates that radical constructivist resultant effect on retention of problem solving skill would be (0.36)(0.23) + 0.54 = 0.62 in standardized beta weight or about 38.44% of the variations in PSR is explained by RCII.

The model shows that the use of radical constructivist teaching approach will contribute most to the development of problem solving skills in mathematics. Success of radical constructivist

intervention in this case may be attributed to the strong individual accountabilities of students for their own learning that sustains the challenge that learning situations have on them. This result also emphasizes the importance of teaching and instructional design in the teaching and learning process. Teachers need to be able to design and formulate radical constructivist interventions in the classroom in order to facilitate more effective learning and retention of problem solving skills.

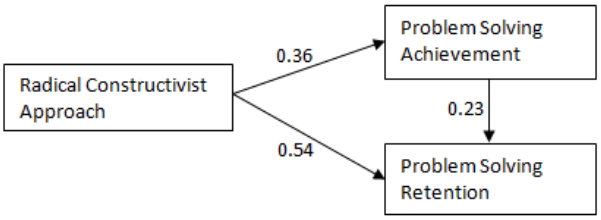

Figure 5. Predictors of problem solving skills and its retention

Procedural Fluency and Procedural Fluency Retention Model

Figure 6 shows a summary of the relationship of procedural fluency and its consequent retention by student to its predictor variables in path analytic model which illustrates that both constructivist instructional interventions directly influence procedural fluency achievement of students. Like conceptual understanding, constructivist interventions also have indirect effects on procedural fluency being mediated by the same affective belief – control orientation. The negative beta coefficients observed in the model is similarly explained in the role of control orientation belief on conceptual understanding earlier discussed.

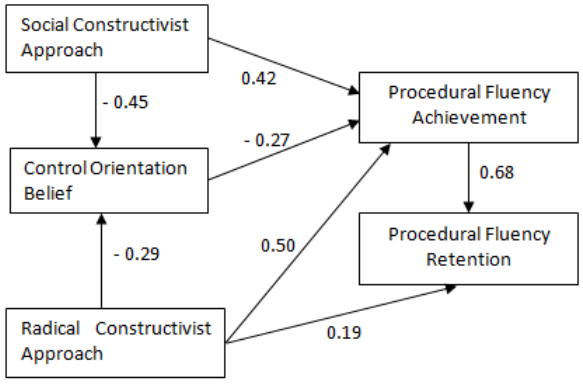

Figure 6. Predictors of Procedural Fluency Achievement and Retention

The path Beta weight of SCII to PFA indicates that more than 16% of the variation in PFA is explained by SCII while PFA directly explains 42.24% of the variation of PFR. In other words, SCII contributes indirectly to PFR by about 8.16% of the variation in PFR. Also, SCII contributes indirectly to the variation of PFA by $[(-0.45)(-0.27)]^2$ percent or 4.47% of the variation in PFA. Moreover, SCII's indirect influence on PFR accounts for about $[(-0.45)(-0.27(0.68)]^2$ or about 0.68%. Overall SCII explains a total of 8.84% of the variation of PFR and 46.71% of the variation in PFA.

The foregoing discussion on the path analytic models for the predictors of achievement and retention of learning as illustrated by Figures 3 to 6 indicated that instructional interventions particularly the constructivist instructional interventions consistently showed strong influence on achievement and retention of learning. Indirect effects were observed either through control orientation as in the case of conceptual understanding and problem solving skills or through achievement measures along procedural fluency and problem solving in the case of retention measures. Radical constructivist intervention proved to be the single predictor of problem solving skill and its consequent retention.

Among the four affective beliefs, only control orientation belief showed to mediate the effects of constructivist instructional interventions particularly on conceptual understanding, procedural fluency, and procedural fluency retention. Achievement measures predicted retention measures specifically along procedural fluency, problem solving skills, and general achievement.

These results partially confirmed the hypothesized relationships among variables. The first hypothesized relationship is that instructional interventions, with the exception of the traditional lecture-recitation, are significant predictors of achievement measures was partially confirmed. It is further supported by the influence of the two constructivist interventions on control orientation. On the second hypothesis, given that the affective beliefs are very highly correlated construct, that at least one of them is a significant predictor of achievement and retention is partially confirmed especially in the case of conceptual understanding and procedural fluency. Finally, the third hypothesis is that some achievement measures, especially general achievement, problem solving skills and procedural fluency are predictors of their

respective retention measures were also partially confirmed.

The foregoing discussions emphasize the importance and robustness of constructivist instructional interventions (especially its radical interpretation where strong individual responsibility is emphasized) in influencing achievement and retention measures. Similarly, compared to the other affective beliefs, the strength of control orientation belief in influencing achievement measures along conceptual understanding and procedural fluency is emphasized. However, interventions to influence control beliefs must be in the form of putting up challenging situation in order for the students to feel doubtful about their ability to control (hence the negative direction of influence) has to be done if achievement measures have to be raised.

The foregoing finding generally confirms the conceptual framework. It is also generally consistent with recent research results on achievement and affect. Santos [41] found that teaching strategies significantly influenced level of efficacy of students as well as achievement of students. Kadijevich [42] found that in computer assisted learning interventions, a strong relationship exists between problem solving and conceptual understanding. This confirms previous research findings that changing classroom environments not only affects thinking and learning [11], [9], [42] but also affects students' affective beliefs [42].

The findings for the most part supported the hypothesized relations between and among variables as envisioned by the conceptual framework and are generally supported by literature as presented earlier. The results also support results of studies on the efficacy of constructivist approaches in science and mathematics education. That is instructional interventions create instructional context that influence affective beliefs as well as achievement and retention. Similarly, that affective belief might mediate the effects of instructional intervention on achievement and retention.

CONCLUSIONS

Considering therefore direct and indirect influences of instructional interventions, affective beliefs and achievement measures, the following conclusions are supported to respond to the three main hypotheses of the study earlier presented.

Instructional Intervention as Predictor Variable

1. That the radical constructivist instructional interventions (RCII) strongly influence all achievement measures as well as their consequent retention.
2. That the social constructivist instructional interventions (SCII) strongly influence all achievement and retention measures except in problem solving skills of students.
3. That the traditional instructional interventions did not significantly influence any of the achievement, retention, nor affective measures.

Affective Beliefs as Predictor Variable

4. That of the four affective beliefsproposed,control orientation belief (COB) significantly influence conceptual understanding achievement (CUA) and procedural fluency achievement (PFA) mediates the effects of constructivist instructional interventions on these measures.
5. That goal orientation belief is a significant predictor of conceptual understanding achievement.

Achievement as Predictor of Retention

6. Among the achievement measures, general achievement (GA), problem solving achievement (PSA), and procedural knowledge fluency influence their corresponding retention measures;

The foregoing conclusions bear direct implication on teaching practice. It is highly recommended that teachers design instructional interventions and learning experiences along constructivist instructional practices especially exploring radical constructivist practice of highly individualized and personally accountable instructional system as used in this study in order to develop problem solving skills among students to the level of mastery. An immediate interesting implication of this study is that the affective beliefs, interest and value beliefs (IVB), efficacy beliefs (EB), and goal orientation belief (GOB) are relatively stable self-referent beliefs not readily affected by instructional context as influenced by instructional interventions.

Moreover, teachers may capitalize on the mediational strength of control orientation belief (COB) in improving achievement. Given the negative relationship of these two affective beliefs on achievement, it is recommended that teachers provide

constant challenge and put pressure on these beliefs by employing constructivist interventions if positive gains on conceptual understanding (CUA) and general achievement(GA) and retention of learning is to be given greater chances to be achieved by students.

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