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Relationship of Inquiry-based Instruction on Active Learning in Higher Education

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ABSTRACT

Inquiry-based instruction is a student-centred approach that can enhance students' confidence, understanding, and academic performance in learning. This study seeks empirical evidence on the effect of Inquiry-Based Instruction on Active Learning and involves a sample of 147 undergraduate students in an institution of higher learning in Malaysia. Confirmatory Factor Analysis confirmed the second-order factor model of Inquiry-Based Instruction which consists of three latent constructs. On the other hand, the Active Learning construct was also represented as a second-order factor model with three latent constructs (Learning Obligation, Learning Effort and Learning Collaboration). Overall, Structural Equation Modeling results provided statistical evidence that Inquiry-Based Instruction has a strong, positive and significant effect on Active Learning in higher education.

Keywords: Inquiry-based instruction, active learning, higher education, structural equation modeling

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INTRODUCTION

Active learning refers to the process of engaging students in activities such as reading, writing, problem solving and reflecting. Such classroom activities put the student at the centre of the learning process enabling them to improve their critical thinking skills in the class. Active learning is often contrasted to the traditional lecture where students passively receive information from the instructor (Prince, 2004). The whole process of active learning is based on the activities and level of student engagement (Prince, 2004). Hence, the core elements of active learning are student activity and engagement in the learning process. Active learning can also be referred to as query learning (Settles, 2010).

Inquiry-based learning is an approach that is integrated in active learning, and involves students in various classroom activities which can enhance their confidence, understanding and help them to achieve academic excellence (Colburn, 2006). In this approach, inquiry triggers students' thinking to enhance their understanding of concepts in a classroom setting. According to Healey (2005), instruction-based learning is a part of the active learning process where students are involved in research-based activities. Normally, inquiry-based instruction is adopted by teachers in institutions of higher learning (IHL, hereafter) to help promote the research activities and link it with the teaching styles. Inquiry-based instruction is commonly used together with active learning in IHL especially in professional fields of study such as engineering, medicine, sociology and statistical education.

LITERATURE REVIEW

Active learning was a buzzword in the 1990s report to the Association for the Study of Higher Education (ASHE) (Bonwell & Eison 1991). This report discussed many different methodologies to promote "active learning" and emphasized the need for students to be actively engaged in the learning process. Instead of just listening and being passive recipients, students need to be actively involved in reading, writing, negotiating to create meaning and engaged in solving problems. In particular, students must be actively engaged in higher-order thinking tasks involving the analysis, synthesis, and evaluation of the learning process (Renkl, Atkinson, Maier & Staley, 2002). Active learning engages students in two aspects, i.e. doing things and thinking about the things they are doing (Bonwell and Eison, 1991). Based on Catrambone and Yuasa (2006), a student's active involvement in the learning process produces the most robust and flexible learning (e.g., Chi, Bassok, Lewis, Reimann, & Glaser, 1989; Renkl, 1999). Hence, active learning is related to a student being able to produce self-explanations. The best instruction and training programs for knowledge acquisition should therefore be those that induce or enhance some type of active information processing on the part of the learner (Dufresne, Gerace, Hardiman, & Mestre, 1992).

Active learning is a two-way process in which the teacher provides opportunities to students to fully understand the content by promoting student involvement (Lamancussa, Zayas, Soyster, Morell & Jorgensen, 2008). Student involvement is directly linked with the academic performance and experience and refers to the devotion of the physical and psychological energy for achieving the excellence in academics (Gibbs & Coffey, 2004). Adoption of active learning is just not about the implementation of techniques in the classroom but the collective effort of teachers and students for maintaining the status quo of the class to achieve the academic target and excellence.

Furthermore, active learning can be conducted through collaborative learning which involves group discussions, role playing and structured learning groups. Collaborative learning refers to students working in groups rather than working individually (Prince, 2004). The approaches of active learning like classroom discussions, debates and various group discussions promotes team work and enhances students' interpersonal skills. Obviously, the goal of active learning is to enable the students to recognize concepts and techniques for solving problems and thereby polish their cognitive skills and enhance critical and creative thinking (Cherney, 2008).

According to Alberta Learning (2004), "inquiry is a dynamic process of being open to the world of wonder and attempt to understand the world" (Galileo Educational Network, 2004). Hence, inquiry education is most effective when students are able to apply the relevant knowledge to their own lives. Myers and Warner (2008) posit that inquiry-based teaching is a teaching method that combines the curiosity of students and the scientific method to enhance the development of critical thinking skills while learning science. A study conducted by Alvarado and Herr (2003) reveal that inquiry-based instruction is a complex process which formulate questions to construct new knowledge and then communicating the learning with colleagues and associates. Beach and Myers (2001) declared that inquiry-based learning initiates with the execution of questions, problems or scenarios. In this type of instruction, the presentation of facts is not sufficient in themselves rather the sense of inquiry and investigation in which questions are answered, and how students are facilitated to memorise the information through the instructional materials that is important. Hanna and Dettmer (2004) advocated that answers to questions are investigated actively by students in inquiry-based learning. Alvarado and Herr (2003) further explained that the inquiry-based approach for teaching promotes intellectual engagement of students and motivates them to improve their performance.

Therefore, Lujan and DiCarlo (2006) stated that inquiry-based instruction enables students to become critical thinkers, problem solvers, and self-directed learners. Inquiry-based teaching instruction shares a common core of teaching ideals with "direct instruction," the "progressive model," and the "constructivist approach," is supported by research done by Jean Jacques Rousseau, John Dewey, and Jerome Bruner. Generally, the instructor facilitates learning through focused instruction for small groups rather than teaching whole groups as in didactic classes. "The teacher's role is to encourage the development of individual potentialities rather than moulding children according to some preconceived pattern" (Rogers, n.d). Hence, lessons are meaningful to students as they are contextualised to real world situations.

In fact, there are many different explanations for inquiry teaching and learning and the various levels of inquiry that can exist. Banchi and Bell (2008) outline four levels of inquiry for our students namely **Level 1**: Confirmation Inquiry, **Level 2**: Structured Inquiry, **Level 3**: Guided Inquiry and **Level 4**: Open Inquiry. Banchi and Bell (2008) emphasise that teachers should begin their inquiry from level 1 to 4 to effectively develop students' inquiry skills. According to Parr and Edwards (2004), the learning of students is dependent on the teaching style that is student-centered. They elaborated that it is like a professor teaching a science lesson in such a way that students are guided to develop their critical thinking skills by encouraging them to raise queries on the topic discussed. Open inquiry activity can only be successful when students are motivated by intrinsic interests and if they are equipped with the relevant skills to conduct their own research project. In fact, it is important for teachers to acquire a deep understanding on how students can be guided throughout their own studies (Yoon, Joung & Kim, 2012) where the plan is provided by the teacher. Teachers at all schools expressed confidence in facilitating inquiry-based learning; however, they did indicate uncertainty in the formulation of a hypothesis (Ramnarain, 2014).

Nonetheless, Stephenson (2008) argues that inquiry is not merely 'having students to do projects' but rather it strives to nurture deep, discipline-based way of thinking. Classroom tasks that are worthy of students' time and attention, relevant, connected to the world and organized around the 'big ideas' of a subject can develop understanding and intellectual interest and engagement with students. Capacity Building Series (2013) for students highlighted that open-ended investigations into a question or a problem require students to engage in evidence-based reasoning and creative problem-solving, as well as "problem finding." In the meantime, the educators also have to be responsive to students' learning needs, and know when and how to introduce students to ideas that will promote inquiry. Obviously, educators need to play an active role throughout the learning process by establishing a culture where ideas are respectfully challenged, tested, redefined and viewed as improvable, moving students from a position of not sure to a position of firm understanding and further research (Scardamalia, 2002). Underlying this approach is the idea that both educators and students work together, and accept mutual responsibility for in the planning and implementation stages of the learning process (Fielding, 2012).

METHODS

The main aim of this study was to investigate the effect of Inquiry-Based Instruction on Active Learning in higher education. The study was conducted at the Faculty of Computer Science and

Mathematics in a public university in Selangor, Malaysia. Data were collected via survey using a questionnaire. The sample comprised a total of 147 undergraduates who were randomly selected from a population of 329 at the faculty. Approximately 50 students were selected from each course of study at the faculty – i.e. the Mathematics, Statistics, and Computer Science Programs. The survey was conducted with the help of the lecturers.

The main aim of the questionnaire was to gauge students' perceptions towards the practices of inquiry-based instruction and active learning in higher education. The students responded to the questionnaires based on a 5-point Likert-scale. The questionnaire was validated by two Teaching and Learning experts from the Faculty of Education in the same IHL involved in this study. Both experts agreed with most of the items used for the measurement of the inquiry-based instruction and active learning in higher education. Comments given were minimal and minor corrections were made for certain items on active learning. Items suggested for correction were b4, b5, c3, c4, d2, d5. Confirmatory Factor Analysis (CFA) was used to test the measurement model and to ascertain convergent validity. Convergent validity can be ascertained if the loadings are greater than 0.5 as refered to Bagozzi and Yi (1991) or preferable 0.7 as stated in Hair et al. composite reliability greater than 0.7 (Gefen, Straub & Boudreau, 2000; Hair et al., 2010) and the average variance extracted is greater than 0.5 (Fornell & Larcker, 1981; Hair et al., 2010). The researchers also tested for the discriminant validity using the Fornell and Larcker (1981) criterion whereby the average variance for each construct should be greater than the squared-interconstruct correlations. The model fit was assessed using absolute fit indices (Chi-Square/df, GFI, AGFI and RMSEA) and incremental fit indices (TLI and CFI). The model fits the sample data well if Chi-Square/df is between 2 and 5, GFI≥0.90 and AGFI≥0.90, and TLI≥0.8 and CFI≥0.9 and RMSEA≤0.08 (Rogers, n.d.). Then, Structural Equation Modeling was used to test the proposed structural model of relationships between the variables of inquiry-based instruction and active learning. CFA and SEM were carried out using IBM SPSS AMOS 22.0.

RESEARCH FINDINGS

Reliability Analysis

The Cronbach's alpha was used to assess the internal consistency reliability. Table I presents the reliability analysis results for Inquiry-Based Instruction (A) which consists of three components namely teaching style (AA1), guided discovery (AA2) and active control (AA3). The Active Learning construct are represented by Learning Obligation (B), Learning Effort (C) and Collaboration Learning (D). The Cronbach's alpha value for AA1, AA2, AA3 B, C and D are 0.900, 0.789, 0.796, 0.804, 0.655 and 0.644 respectively. These values exceeded 0.60 indicating that the items are reliable for measuring the respective constructs.

Table 1
Reliability analysis

Factors	Items	Cronbach alpha
AA1 (Teaching Style)	a12, a13, a14, a15, a16, a17, a18, a19, a20	0.900
AA2 (Guided Discovery)	a1, a2,a3, a5,a10,a11	0.789
AA3 (Active Control)	a4, a6, a7, a8, a9	0.796
B (Learning Obligation)	b1,b2,b3,b4,b5,b6,b7,b8,b9,b10	0.804
C (Learning Effort)	c1,c2,c3,c4,c5,c6,c7,c8,c9,c10	0.655
D (Collaboration Learning)	d1,d2,d3,d4,d5,d6,d7,d8,d9	0.644

Factorial Validity of Inquiry-Based Instruction

Confirmatory factor analyses were performed using IBM SPSS AMOS 21.0 to assess the validity and reliability of the A, B, C and D measurement model. Figure 1 illustrate the first-order three-factor structure model. All standardized loading showed greater than 0.5. The overall model chi-square (χ^2) was 236.349 with 167 degrees of freedom, $p < 0.05$, $\chi^2/df = 1.415$, GFI=0.860, AGFI=0.824, TLI=0.934, and RMSEA= 0.053. Ideally, the value of χ^2/df should be between 2 to 5, however a value of 1.415 indicates that the model is still acceptable. Thus, the result showed an acceptable fit of the model to the data.

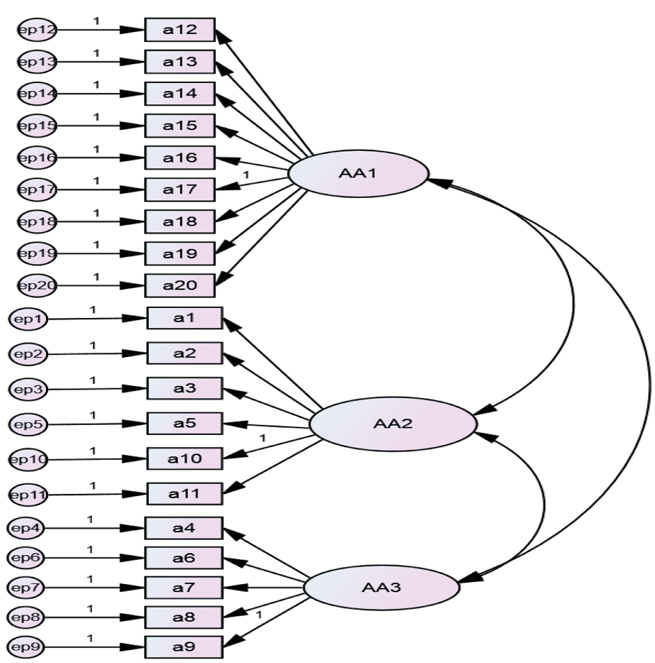

Figure 1. First-order CFA model (Inquiry-based instruction)

Factorial Validity of Active Learning

Active learning was measured by three factors with 29 items. Figure 2 illustrates the first-order three-factor structure model and Table 2 shows the model fitness before and after modification is done. Some modifications involved the deletion of items with low factor loadings to improve the model fit. The initial standardized loading showed that 2 items from variable B (b4 and b5), 5 items from variable C (c3, c4, c5, c6, and c7) and 2 items from variable D (d2 and d5) have a standardized loading below 0.40 and were deleted. The overall model chi-square (χ^2) was 464.481 with 167 degrees of freedom, $p < 0.05$, $\chi^2/df = 2.781$, GFI=0.759, AGFI=0.697, TLI=0.682, CFI=0.721, and RMSEA= 0.110. Thus, the results still showed a poor fit of the model to the data and modification of the model is needed. Based on modification indices, the errors (e29 and e30) for items b9 and b10 on the feedback and (e41 and e40) for items d1 and d4 on teamwork were correlated. The model fit improved when these modifications were carried out ($\chi^2/df = 2.275$, GFI=0.798, AGFI=0.743, TLI=0.772, CFI=0.802 and RMSEA= 0.093). The Cronbach's Alpha for B, C and D after some items were deleted are 0.814, 0.716 and 0.800 respectively.

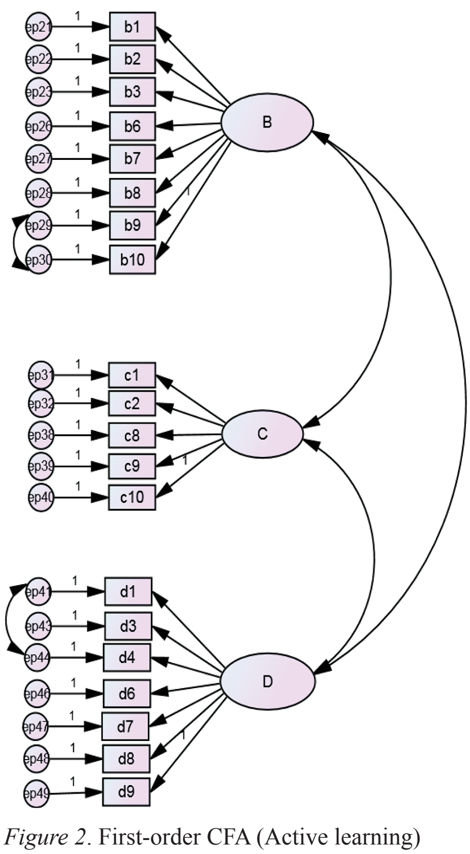

Figure 2. First-order CFA (Active learning)

Table 2
Summary fit indices (First-order Model)

Models		χ^2/df	RMSEA	GFI	TLI	AGFI
Inquiry-based Instruction (A)	Initial	1.415	0.06	0.860	0.934	0.824
Active Learning	Initial	2.450	0.100	0.692	0.571	0.642
	M1	2.781	0.110	0.759	0.682	0.697
	M2	2.275	0.093	0.798	0.743	0.772

Active Learning: Initial: Model with 29 items; M1: Model with items deleted; M2: Model with errors correlated.

The second-order CFA was then performed for construct A. Figure 3 shows the second-order model for A with three first-order constructs. The results for the second-order CFA are shown in Table 3. The fit indices show that the second-order CFA for construct A have a good fit and reasonable error of approximation (GFI=0.860, AGFI=0.824, TLI=0.943, CFI=0.942, RMSEA=0.053, χ^2/df=1.415).

Table 3
Summary fit indices (Second-order Model)

Models	χ^2/df	RMSEA	GFI	TLI	AGFI
Inquiry-Based Instruction (A)	1.415	0.053	0.860	0.943	0.824
Active Learning	2.275	0.093	0.798	0.772	0.743

CFA of the Second-order factor A (Figure 3) with three latent constructs (AA1, AA2, AA3) examined the covariance structure for all latent constructs together. The measurement model does fit well (GFI=0.860, AGFI=0.824, TLI=0.943, CFI=0.942, RMSEA=0.053, even though χ^2/df=1.415 is a bit low, however, the low RMSEA (0.053) indicates the measurement model can be accepted.

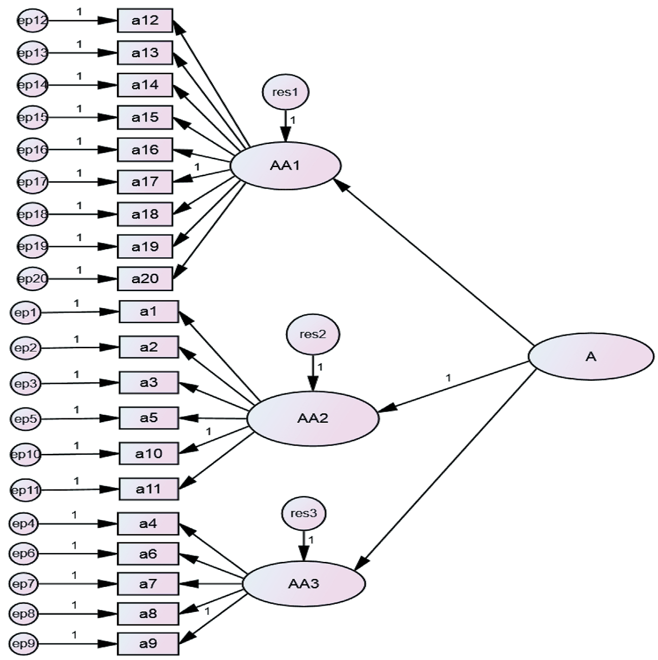

Figure 3. Second-order CFA model (Inquiry-based instruction)

The second-order CFA was then performed for the second order measurement model for active learning in Figure 4. The fit indices show that the second-order CFA for construct active learning has reasonable acceptable indices (χ^2/df=2.275, GFI=0.798, AGFI=0743, TLI=0.772, CFI=0.802, RMSEA=0.093).

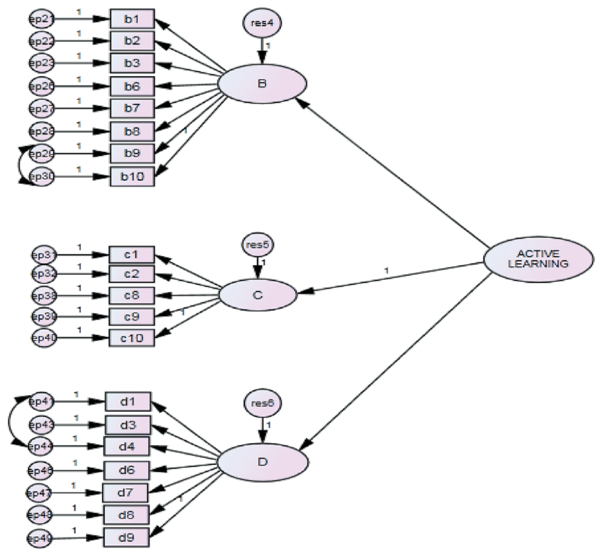

Figure 4. Second-order CFA model (Active learning)

Figure 5 presents the overall measurement model. The fit indices (χ^2/df=1.578, GFI=0.720, TLI=0.817, CFI=0.828, RMSEA=0.063) indicates the measurement model and structural model can be accepted, even though the χ^2/df=1.578 is a bit low.

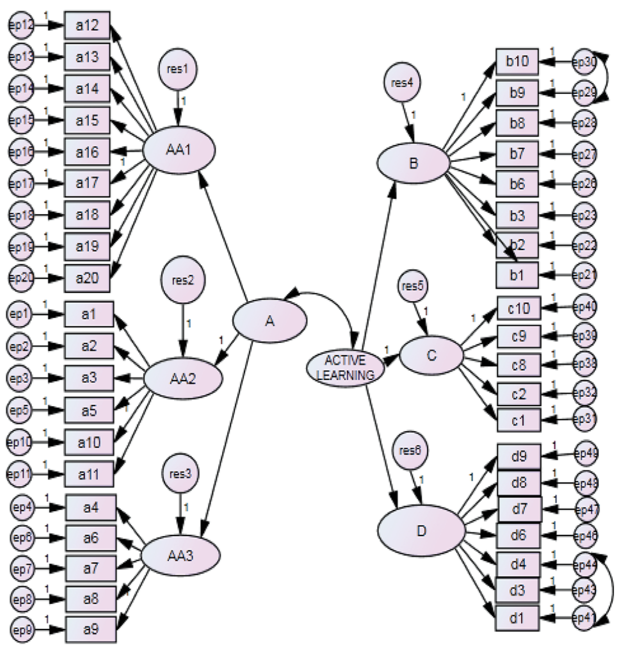

Figure 5. Overall measurement model

Table 4
Summary of fit indices

Model	χ^2/df	RMSEA	GFI	AGFI	TLI
Overall Measurement Model	1.578	0.063	0.720	0.686	0.817
Structural Model	1.578	0.063	0.720	0.686	0.817

Convergent Validity and Discriminant Validity

Table 5 presents the AVE, contsruct reliabilities (CR) and squared-interconstruct correlation (SIC).

Table 5
Summary of AVE, CR and SIC

Construct	Inquiry-Based Instruction (A)	Active Learning
Inquiry-Based Instruction (A)	**0.720** (0.88)	
Active Learning	0.514	**0.761** (0.905)

Notes: Boldface values on diagonal are AVEs; Construct Reliability (CR) values in parentheses and off-diagonal values are SIC

The AVEs for both Inquiry-Based Instruction (0.720) and Active Learning (0.761) are above 0.5 and the construct reliabilities (0.88) are greater than 0.7, The AVE of each construct are also greater than the squared-interconstruct correlations (0.514), thus indicating that discriminant validity has been established.

Structural Model

Next, we proceeded to test the structural model in Figure 6. The results for the Structural Model are shown in Table 4. The fit indices show that generally the structural model can be accepted (χ^2/df=1.578, GFI=0.720, TLI=0.817, CFI=0.828, RMSEA=0.063).

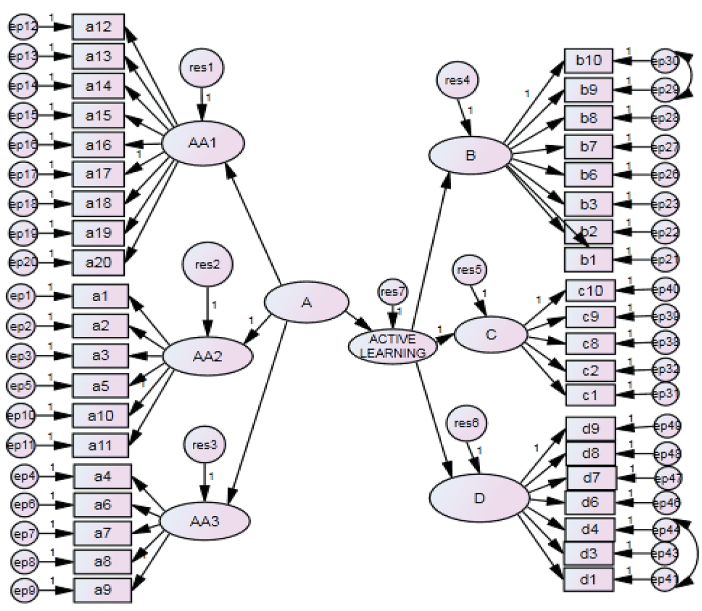

Figure 6. Structural Model

This study found that inquiry-based instruction has a positive and significant effect on active learning (b=0.717, p<0.05). The R-square is 0.514 indicating that inquiry-based learning can explain 51.4% of the variance of active learning. Table 6 shows the standardized path estimates for the effect of inquiry-based instruction on active learning.

Table 6
Standardized path estimates

	Unstandardized beta (SE)	Standardized beta	Findings
Inquiry-Based Instruction ->Active Learning	0.836** (0.159)	0.717	Hypothesis supported

***p-value<0.001; SE=standard error

DISCUSSION AND CONCLUSION

The results of Structural Equation Modeling used in this study indicated a strong, positive and significant relationship between inquiry-based instruction and active learning in higher education. In fact, previous studies have also shown the positive/significant relationship of active learning strategies. In addition, the inquiry training model has a statistically significant effect over traditional teaching method on student academic achievement (Pandey, Nanda, Ranjan, 2011; Akpulluku & Gunay; 2011). Furthermore, Ali (2014) showed the presence of a positive significant relationship between the achievements of students who have been taught using inquiry-based instruction and those who have been taught using the traditional teaching method. Minner, Levy & Century (2010) also support the view that inquiry based instruction has a positive impact not only on student learning outcomes but that it also encourages the retention of the key topics and concepts.

Hence, the conclusion can be drawn from the findings that the active thinking and involvement from the students in the investigation process directly resulted in increased understanding of concepts. Obviously, Inquiry-based instruction is designed to place students at the centre of the learning process with teacher playing the role of guide and facilitator. This concept is different from the traditional classroom where the teacher is viewed as a sage on the stage in a direct instruction classroom (White-Clark, DiCarlo & Gilchriest, 2008). This type of constructivist learning environment promotes students' curiosity and motivates them to investigate their areas of interest associated with the material, which promotes autonomous learning.

There is general consensus in the literature regarding the positive impact of constructivist approaches on student learning outcomes (Burris & Garton, 2007). Herman and Knobloch (2004) found that the constructivist approach such as inquiry-based instruction and active learning generated impact in affective and cognitive outcomes. They also reported that students preferred the constructivist approach because they are allowed to take responsibility for their own learning outcomes. It is exciting to see students building connections, sharing their own learning experiences with others in the classroom, and working together as a team. Consequently, students are motivated by inquiry learning because they are actively involved in the process of finding answers. Furthermore, teachers believe that inquiry-based instruction will have a positive effect on learners by stimulating the gradual infusion of inquiry in the classroom practice (Ramnarain, 2014). Hence, inquiry-based learning should be viewed as an integral part of the active learning approach.

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APPENDIX QUESTIONNAIRE

SECTION A INQUIRY-BASED INSTRUCTION

No.	In the class, my lecturer…
a1	reflects his/her lesson and always makes improvement.
a2	encourages students to discover fundamental principles on their own.
a3	prepares authentic tasks within the context of the curriculum.
a4	helps students gain active control (e.g. ask question when they have doubts) over their thinking process.
a5	believes that guided discovery is more effective than self-discovery in students' learning.
a6	encourages students to connect evidence to knowledge.
a7	asks questions about students' viewpoints.
a8	facilitates the process of gathering and presenting information
a9	encourages students to solve problems.
a10	praises students' performance.
a11	gives clear instruction before expecting students to discuss it on their own.
a12	designs rubrics to support inquiry learning
a13	adjusts grading processes to accommodate new learning approaches.
a14	clarifies value of mistakes in learning.
a15	uses technology to advance inquiry in the class.
a16	ensures a conducive learning environment for the students.
a17	collaborates with students beyond the physical classroom.
a18	encourages students to work with experts and other organizations.
a19	models deep, extended critical thinking.
a20	allows students to plan and carry out their learning experiences.

SECTION B LEARNING OBLIGATION

No.	Statement
b1	I develop a capacity to deal with complexity and ambiguity.
b2	I am open-minded.
b3	I actively participate in discussion.
b4	I study what will be tested in the exams.
b5	I predict exam questions/ topics.
b6	I am intellectually independent.
b7	I acquire graduate attributes.
b8	I respect and comply with academic conventions (e.g. plagiarism).
b9	I provide feedback on their lecturer's teaching qualities.
b10	I provide feedback to the university on the learning environment.

SECTION C LEARNING EFFORT

No.	Statement
c1	I do the same amount of study each week, regardless of whether an assignment is due.
c2	I carefully select what I study and learn in the course.
c3	I study only things that are going to be covered in the assignments.
c4	I have to study constantly if I want to do well in this course.
c5	I could do well without studying much in this course.
c6	I use seniors' work for my assignments.
c7	I put in more effort when assignments are due.
c8	I search for relevant and current materials for my assignments.
c9	I like doing assignments that require field work (e.g. case studies).
c10	I enjoy doing assignments which demand critical thinking skills.

SECTION D COLLABORATION LEARNING

No.	Statement
d1	I enjoy working with my peers in completing our group assignments.
d2	I do better in individual assignments than group work.
d3	I use problem-solving techniques in my study team.
d4	There is a spirit of cooperation within my study team.
d5	There are 'passengers' within my study team.
d6	I take opportunity for all ideas to be exchanged within my study team.
d7	I coordinate with relevant individuals and groups.
d8	I collaborate with my peers in doing assignment.
d9	My creativity and critical thinking are enhanced in group work.