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Artificial Intelligence–Supported Concept-Based Activities and Self-Concept Development in Learning General Science at the Elementary Level

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Abstract

Self-concept is a crucial psychological construct that significantly influence the psychological academic performance, motivation and engagement, particularly at elementary level, In science education many young learners develop negative self-perceptions due to abstract self-concept, lack of individualized self-instructions and traditional teachers self-centered pedagogies. with the rapid advancement pf educational technologies, artificial intelligence supported concept-based activities of learning experience. This study investigates the effect of artificial intelligence supported concept-based activities on self-concept development of elementary school students in learning general science. The experimental group received the instructions using concept-based activities (CBA), while the control group received the instructions using traditional lecture methods (TLM). The study found that both boys and girls in the experimental group improved significantly in achievement and self-concept development scale scores. After twelve weeks of teaching to both groups the researcher administered posttest to both groups The analysis of collected data was done by using mean scores, standard deviation and paired sample t-test, with Cohens D for effect of size to compare student's self-concept in both groups. The results showed a significant difference between scores in two groups. The (CBA) Concept-Based Activities as independent variable is effective practice for experiment. The Piers Harris children's Self-concept development scale was used before and after treatment. Statistical Analysis revealed a significant improvement in the self-concept of students. Statistical analysis revealed a significant improvement in the self-concept development of students exposed to AI supported concept-based learning compared to those taught thought traditional lecture methods. The findings suggest that integrating AI in to elementary science education not only enhance conceptual understanding but also influences students' academic self-concept, confidence and engagement. This study highlights the pedagogical value of AI driven learning environments in fostering both cognitive and effective development among young learners at elementary level.

Keywords: Artificial Intelligence (AI), Concept-Based Activities (CBA), Self-Concept Development (SCD), General Science (GS), Elementary Education (E- E), Pieris-Harris Scale (PHS), Experimental group (EG), Control Group (GP).

Vol. 3 No. 12 (2025)

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INTRODUCTION

Elementary school education is crucial in forming student attitudes, perception of learning, and cognitive capacities. For academic success self-concept thought to be a major predictor, among the one psychological factor. In academic factor self-concept development among students is a major factor, moreover, in an academic setting, self-concept, a person's assessment of their own skills and value influence, drive, preservice, and success. Students learn basic scientific concepts about their environment, physical phenomena, a living thing in elementary and general science. However, traditional lecture method approaches frequently involve rote memorization and teacher centered delivery, which may not be sufficient to meet the needs of individual students. As a result, many students develop low confidence and negative self-concepts regarding science learning at very early age. Various researchers described that some of the diversity of approaches that had been adopted to describe self-concept in the context of learning (Burns, 1982; Eggen et al,2001, 2007). Many researchers (Burns, 1982; Shavelson & Bolus,1976, 1982; Hatti & Marsh, 1996; Mercer, 2011, Harter, 2015) had seen the multidimensional and multifaceted nature of self-concept, even in one area of life.

Artificial intelligence (AI) has drawn more attention in the field of education in recent years because of its capacity to customize learning experiences, offer instant feedback, and modify content to meet the needs of individual students. AI can promote deeper comprehension, active participation, and meaningful learning when paired with concept-based activities. Concept-based learning allows students to connect knowledge across contexts by emphasizing comprehension of fundamental concepts rather than memorization of discrete facts.

This study investigates how elementary students' self-concept development in learning general science is impacted by AI-supported concept-based activities. The study enhances to the expanding quantity of research on AI-enhanced pedagogy and educational psychology by addressing both the cognitive and affective aspects of learning.

REVIEW OF RELATED LITERATURE

Concept Based Learning in Science Education

Concept- based learning places more emphasis on comprehending important concepts, relationships, and ideas than it does on learning specific facts by heart, this method aids in the development of higher order thinking abilities in science education, including reasoning, analysis and problem solving. Learning becomes more meaningful and interesting when concept-based activities promote inquiry, discussion and application of knowledge. The idea of self-concept had appeared in numerous articles in recent years. The concept had been created to represent an evaluation of competencies and feelings of self-worth (Pajares & Schunk, 2005). Hence, it was considered to be the sum of total views that person had of himself and consist of beliefs, evaluations and behavioral tendencies (Strangor, et al., 2022& concept & categories, 2022). Researchers noted the way very young children start to be able to discriminate between themselves (Harter, 1996; Harter & Bukowski,2015). Eggen & Kauchak, 2001,2007).

The focus of Ausubel and Robinson (1969) study lay in the tradition classroom were, under the direction of a teacher, the learners might be able to come to meaningful learning: making sense of the world around. He developed a very powerful insight from his many observations where he was able to separate out the extent of meaningful learning from the extent of teacher direction. In simple terms, the teaching extent of meaningful learning

Vol. 3 No. 12 (2025)

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from the extent of teacher direction. In simple terms, the teaching method was not the critical factor in determining the extent of understanding. He expressed this as a simple diagram (figure 2.1).

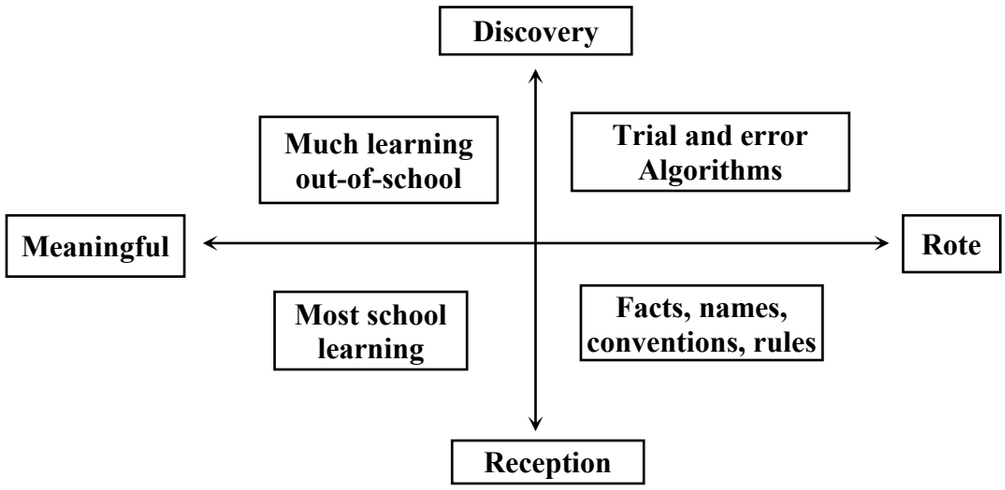

Figure 2.1: Ausubel's Observation

Learning was considered to be rote learning if it did not form a link with brain. Meaningful learning involves the new information being related in a meaningful way to what was already understood. In this, concept formation using AI supported activities might play a major role. The significance of the insight implicit in the diagram was often lost today. Extent of understanding was not dependent on teaching method. It was dependent on how the method was employed and this relates to working memory, a point emphasized strongly explained (Kirschner et al., 2006). However, another insight from Ausubel (2000) was also very important. Extent of understanding depends very heavily on previous understandings. Meaningful learning cam be seen as the formation of viable relationships among ideas, concepts and information (Williams & Cavello, 1995, William &Mann,2017). Therefore, Novak (2006) stresses this when he emphasizes that meaningful learning involves a commitment to link new information with previous information and ideas understood. This involves an attitudinal element. If, for example, the examination system only rewards the correct recall of information, there was no positive motivation for a learner to seek for understanding, despite the fact that understanding (meaningful learning or making sense of) was the natural process.

Concept based teaching and learning improves students' conceptual comprehension and AI supported scientific knowledge, according to research, Additionally, students' confidence and self-concept tend to improve when they successfully grasp concepts

1.1 MEASUREMENT OF SELF- CONCEPT

The Piers-Harris Self-Concept Scale (PHCSCS) in its various versions (Piers & Harris, 1964; Piers, 1984; Piers & Herzberg, 2002) had been employed in many different studies and had been to refer to in many other studies, especially in educational psychology, clinical psychology and psychological development. It had been employed in relation to general science and other science subjects.

Its use was widespread (Holmbeck et al., 2008; Piers & Herzberg, 2002; Oriel et al., 2008; Remine et al., 2009) and its psychometric properties well documented. It appeared to be

Vol. 3 No. 12 (2025)

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valid across different social and cultural settings (Flahive et al., 2011; Flahive et al., 2015; Piers, 1984; Piers & Harris, 1964), including with learners from specific populations including those with various kinds of special needs (Piers & Herzberg, 2002). The Piers-Harris scale-III (Third Edition) was recently used to measured self-concept in children and young children (Piers et al., 2018).

Outcomes had been related to other variables such as extracurricular variables (Flahive et al., 2015), the observation of the psycho-sociological environment of the classroom, school disruption and academic success, disturbing behaviors, sociability motivation and study methods, the self-concept development towards reading , the construction of citizenship projects, eating behavior related to self-concept development scale (Piers & Herzberg, 2002) and fatness and self-concept development in science subjects (Diana, 2011). School readiness comprised factors related to level of self-concept that was included on popularity, intellect in class, freedom of popularity, feeling of happiness and gratification as well as physical appearance and characteristics. The purpose of this study was to analyze the relationship between the level index of body mass and self-concept development of students at primary level (Piers & Herzberg, 2002).

The questionnaire employed dichotomous scale responses. In this study, it seemed more appropriate to extend this to responses on a six-point scale, thus giving, potentially, enhanced discrimination. It was also decided to go for the use of each item in only one dimension of the scale, considering the factorial saturation and apparent validity and content of the item. This gives a short version of the scale, with established reliability and validity, in order to explore how students at elementary level develop in terms of self-confidence arising from new ways in presenting the science curriculum. This study aimed to build on the suggestion made in previous investigations (Veiga & Leite, 2016), improving the psychometric qualities of the Piers-Harris (PHCSCS) scale and, subsequently, the possibilities of gathering information that was more consistent with the theoretical foundation for self-concept building in general science. The goal was to relate the development of self-concept and link this to academic achievement both in terms of knowledge retention as well as conceptual understandings along with retention rates (students not being allowed continue on with studies in the sciences but repeating the year or course The version developed in this study involved 30 items of the modern Piers-Harris (PHCSCS-2) scale, changing the type of response from dichotomous (yes or no) to response 1 (completely disagree) to 6 (completely agree). The existence of a similar number of items for factors (5 in each factor) promotes the clarity of the evaluation and reduced the response time. The external validity had been demonstrated by Leite (forthcoming). Previous studies had shown that the scale had good psychometric qualities, the most important of these being validity.

Artificial Intelligence in Science Education

Artificial intelligence has revolutionized education by making data driven feedback, intelligent tutoring, and adaptive learning systems possible. Artificial intelligence (AI) tools are capable of tutoring, and adaptive learning system possible. Artificial intelligence (AI) tools are capable of analyzing students learning styles, spotting misconceptions, and offering tailored instruction. This customized method encourages self-paced learning and lessens learning anxiety. Many facets of how conceptual understanding skills grew with age were explored by developmental cognitive psychology and was explained in practice and theory of individual psychology (Adler& Radin, 2014) several studies have reported positive

Vol. 3 No. 12 (2025)

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Print ISSN 3006-466X

effects of AI supported learning environments on student's engagement, achievement and motivation. However, limited research has focused specifically on the impact of AI on effective outcomes such as self-concept, particularly at the elementary level.

OBJECTIVES OF THE STUDY

The following were the objectives of the study:

- To examine the effect of AI-Supported concept-based activities on self-concept development in elementary school students learning general science
- To compare the self-concept of students taught through AI-based instruction with those taught through traditional teaching methods

RESEARCH HYPOTHESES

- $H_{o1:}$ there is no significant difference between the mean self-concept development scores scale of boys' experimental group taught through concept-based activities (TTCBA) using AI-supported activities in general science before and after treatment
- $Ho_{2:}$ there is no significant difference between the mean self-concept development scores scale of girls' experimental group taught through activities through concept-based activities (TTCBA) using AI supported activities in general science before and after treatment
- $Ho_{3:}$ there is no significant difference between the mean self-concept scale scores of boys' control group not taught through concept-based activities (NTTCBA) not using AI-supported activities in general science before and after treatment
- $Ho_{4:}$ there is no significant difference between the mean self-concept development scale scores of girls' control group not taught through concept-based activities (NTTCBA)not using AI-supported activities in general science before and after treatment

RESEARCH METHODOLOGY

The study was experimental in nature, factorial 2x2 design was used at two levels with two groups, both of which were formed by random assignment (Lodico & Voegtle, 2010) based on literature review (Creswell, 2014). The one variable was method and the other variable was gender (use of AI supported concept-based method for experimental group and there is no use of concept-based method for control group) (Spaulding, et al , 2013)

Table 3.1: ***A 2x2 Factorial Design***

	Boy students	***Girl students***
No treatment	Cell-1 Boy students who got no treatment	Cell-2 Girl students who got no treatment
Treatment	Cell-3 Boy students who got treatment	Cell-4 Girl students who got treatment

To conduct the experiment two government girls'/boys' schools were selected in addition,50 boys and 50 girls selected for both groups from two schools. The total sample divided in to four strata, for example from 107 population 100 sample chosen For Experimental Group (n = 25) boys and (n = 25) girls' students where students were engaged through concept-based activities for measuring the effectiveness of Piers- Haris scale (PHCSCS-2) reflection among students, the control group was also consisting of (n = 25) boys and (n = 25) girls in which traditional techniques were applied for effectiveness measurement of self -concept attainment in subject of general science. The outliers were removed from the study (Muijs, 2004). The selected students were divided into two groups (1) experimental group (2) control group. Each group composed of 50 students. The

Vol. 3 No. 12 (2025)

Journal of Social Signs Review

Online ISSN 3006-4651

Print ISSN 3006-466X

content validity was established by using expert judgmental procedures. Reliability of Piers- Harris scale (PHCSCS-2) was determined using Cronbach Alpha. It was lies between 0.6 to 0.8.

PROCEDURE

An experiment was conducted at Government Girls Primary School Dingi and Government Boys Primary school Dingi Haripur.107 students were enrolled in both boys' and girls' primary schools. The 7 outliers were removed. The 50 male and 50 female in both schools were chosen in subject of general science. Binary groups were formed consisted of 50 male and 50 females taken to conduct the experiment, further consisted of 25 pairs (25 Boys and 25 Girls) for experimental group, same repetition was applied on control group also consisted of 25 pairs (25 Boys and 25 Girls) Appropriate agenda was achieved for both groups.

The self- concept development scale was based on PHCSCS-2(PIERS-HARRIS) scale. To check self-concept development of students PHCSCS-2 scale was applied for both groups before and after treatment (Piers-Harris & Herzberg, 2002) and the recent research study showed the structure and construction of Adolescent self-concept short scale Adolescents (ASCSS) (Veiga & Domingues, 2012) used for Portuguese adolescent students and this short scale was used for children of grade 5 level in recent study PHCSCS-2 consisted of 30 items for self-concept development of students as initial and final treatment. This scale was again used and adopted form adolescent's self-concept buildings (Veiga et al., 2016). For self-concept development, Piers-Harris (PHCSCS-2) scale was used consisted of 30 items was applied in present research study. Suitable changes were made in classroom for teaching to both groups (experimental/ control) before and after treatment after expert's consultation of doctoral committee of UOH (University of Haripur).

RESEARCH INSTRUMENT

The Pier-Harris Children's Self-Concept Scale was used to measure students' self-concept using AI SUPPORTED TECHINIQUES. The scale is a standardized and reliable instrument widely used to assess self-concept in children across multiple dimensions. The self-concept development scale (PHCSCS-2) was used in this study to measure the self-concept of students towards general science (Piers & Herzberg, 2002). The scale consisted of 30 items for self-concept development of students and was adopted from the adolescent's self-concept development for Portuguese adolescents' students. The researcher herself adopted the free version short scale for children (self-concept development scale PHCSCS-2) after expert consultation with the doctoral committee of UOH in district Haripur (Appendix-B). The scale was comprised of six factors: anxiety (nervousness) (AN), physical (bodily) appearance (PA), behavior (BE), popularity (admiration) (PO), happiness (HA), and intellectual (intelligent) status (IS). Each subject's score was calculated from one to six based on the related assignment number and its sub-parts, consistent with the subject's selection from totally disagree to totally agree (level 1 to 6). In the case of opposite items, the reverse of the arithmetic value of the items was applied first. The self-concept development scale was administered before and after treatment to assess the self-concept of students.

POPULATION AND SAMPLE

The population of the study was elementary school student's male and female studying general science. A sample of 100 students was selected using stratified sampling technique

Vol. 3 No. 12 (2025)

Journal of Social Signs Review

Online ISSN 3006-4651

Print ISSN 3006-466X

from public school of locality for example GGHSS-Dingi District Haripur was chosen for the said study. The sample was divided I to two groups:

- Experimental Group (N = 50): Trained Using AI supported Concept-Based Activities (CBA).
- **Control Group (N= 50): Trained Using Traditional Lecture Method (TLM).**

DATA COLLECTION

The data was collected by researcher through research instruments using Piers-Harris scale (PHCSCS-2) before and aftertreatment, the data was in the form of 30 items/statements, The data was collected from experimental and control group using AI supported techniques.

DATA ANALYSIS

Data analysis was done by using descriptive statistics like mean score, standard deviation, and inferential statistics like, paired sample -t-test use for calculation and the effect of size measured by Cohen's D formula was applied

RESULTS

The following is the results of the study

Table 1:: ***Comparisons of Boys' Experimental Group in Self-Concept Scale Scores before and after Treatment***

Test	N	Mean	SD	SE Mean	Correlation (p)	Paired Difference			t (p)
						M	SD	SEM	
Post	25	93.32	13.41	2.68	- 0.140 (0.505)	24.12	23.04	4.60	5.23 (0.000)

Table 1 shows that self-concept development scale scores experimental group TTCBA group in pre- test (N=25, Mean=69.20SD Score=16.95, SE Mean=2.68) and in posttest (N=25 Mean =93.32, SD Score =13.41SE Mean=2.68). The value of correlation (r=- 0.140) p=0.505> 0.05 also showed a non- significant relationship between post and pre-self-concept scores. Paired differences of posttest and pre-test Mean=24.12 SD=23.04 SE Mean=4.60. The difference of SAT scores between pre -test and post-test is statistically significant as t-value=5.23, p=0.000 < 0.05.

Table 2: ***Comparisons of Girl's Experimental Group in Self-Concept Scale Scores before and after Treatment***

Test	N	Mean	SD	SE Mean	Correlation (p)	Paired Difference			t (p)
						M	SD	SEM	
Post	25	105.44	8.29	1.65	- 0.22 (0.291)	37.36	20.31	4.60	9.19 (0.000)
Pre	25	68.08	16.81	3.36					

Table 2 shows that self-concept development scale scores experimental group TTCBA group in pre- test (N=25, Mean=68.08, SD Score=16.81, SE Mean=3.36) and in posttest (N=25 Mean =105.44, SD Score =8.29 SE Mean=1.65). The value of correlation (r=- -0 022) p=0.291 >0.05 also showed non-significant relationship between post and pre-self-concept scores. Paired differences of posttest and pre-test Mean=37.36 SD=20.31SE Mean=4.60. The

Vol. 3 No. 12 (2025)

Journal of Social Signs Review

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Print ISSN 3006-466X

difference of self-concept scores between pre -test and post-test is statistically significant as t-value=9.19, p=0.000 < 0.05.

Table 3: Comparisons of Boys' Control Group in Self-Concept Scale Scores before and after Treatment

Test	N	Mean	SD	SE Mean	Correlation (p)	Paired Difference			t (p)
						M	SD	SEM	
Post	25	82.04	12.04	2.40	-0.359 (0.078)	38.88	12.32	2.46	15.7 (0.000)
Pre	25	43.16	9.37	1.87					

Table 3 shows that self-concept development scale scores control group NTTCBA group in pre- test (N=25, Mean=43.16, SD Score=9.37, SE Mean=1.87) and in posttest (N=25 Mean =82.04, SD Score =12.04 SE Mean=2.40). The value of correlation (r =- -0. 359) p=0.078 >0.05 also showed non- significant relationship between post and pre-self-concept scores. Paired differences of posttest and pre-test Mean=38.88SD=12.37 SE Mean=2.46. The difference of self-concept scores between pre -test and post-test is statistically significant as t-value=15.77, p=0.000 < 0.05.

Table 4: Comparisons of Girl's Control Group in Self-Concept Scale Scores before and after Treatment

Test	N	Mean	SD	SE Mean	Correlation (p)	Paired Difference			t (p)
						M	SD	SEM	
Post	25	81.68	8.44	1.68	-.0.037 (0.860)	13.96	11.74	2.34	5.94 (0.000)
Pre	25	67.72	7.85	1.57					

Table 4 shows that self-concept development scale scores control group NTTCBA group in pre- test (N=25, Mean=67.72, SD Score=7.85, SE Mean=1.57) and in post-test (N=25 Mean =81.6, SD Score =8.44 SE Mean=1.68). The value of correlation (r=- -0 037) p=0.806 > 0.05 also showed non- significant relationship between post and pre-self-concept scores. Paired differences of posttest and pre-test Mean=13.96 SD=11.74SE Mean=2.34. The difference of self-concept scores between pre -test and post-test is statistically significant as t-value=5.94, p=0.000 < 0.05.

The result showed that the experimental group indicated a significant improvement in self-concept developments as compared to control group. The mean score in posttest in self-concept development of students exposed to AI supported concept- based activities was higher than that of students taught through traditional lecture methods. The paired sample t-test and Cohen's D, results revealed that statistically significant difference at 0.05 level, leading towards the rejection of null hypothesis.

DISCUSSION

The results of the study validate that AI-supported concept- based activities positively effect self-concept development in elementary science learners, the modified nature of AI -based instructions allow students to learn their own pace, receive immediate feedback, and experience success in understanding scientific concepts and scientific ideas. This experience contributed to enhanced confidence and positive self-concept development among students using the self -concept development scale (PHCSCS-2). The study also explores and compares the effectiveness and usefulness of different teaching tactics for

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concept attainment vat elementary level, which helps clarifying the boundaries of their understanding of the general science subject. Concept -based activities helped students move beyond rote memorization and develop a deeper understanding of scientific ideas and Build General Science concepts among students at elementary level. When students successfully grasp concepts, their sense of competencies increases, leading to improve self-concept. This result aligns with previous research highlighting the benefits of student -centered and AI technology-enhanced learning environments.

CONCLUSION

Instructors and policy makers are fortified to include AI-driven concept-based strategies in elementary class rooms to support academic, psychological, emotional and self-concept development. This ability helps in development of cognitive and meta cognitive abilities of students. The study concludes that integrating artificial intelligence with concept-based activities in elementary education has a significant positive effect on students' self-concept development.AI supported learning environments not only enhance conceptual understanding but also foster, engagement, confidence and positive attitudes towards learning General Science at elementary level.

RECOMMENDATIONS

- Teachers should integrate AI- supported concept -based activities in elementary science education
- Training programme should be provided to educators to effectively use AI tools in classroom level.
- Future research should explore the long-term effects of AI- based learning on self-concept and academic achievement.
- Similar studies may be conducted at different educational level and across different level subjects like biology, chemistry, physics, math etc.
- It is clear from the previous conclusion that science teachers should embrace effective concept-based activity strategies to boost students' academic progress.
- Future studies also required to explore the impact of concept- based activities (CBA) and traditional learning methods (TLM) for learning together and group investigation on both basic and integrated concept-based activities and self-concept development skills at different grade leve

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