Journal of Educational Research and Reviews
Vol. 9(8), pp. 221-229, August 2021
doi: 10.33495/jerr_v9i8.21.135
ISSN: 2384-7301
Research Paper

Understanding assurance of learning in light of experiments, errors and sampling methods

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Accepted 2nd July, 2021.

Abstract. The objective of this paper is to bring a clear understanding of experiments, the effect of errors and sampling methods used in effective learning among students known to be the assurance of learning (AoL). Extant literature was referred to explore the gaps as; experimentation adoption in AoL implementation is very limited and effects of errors are not being identified and reported, making it difficult to generalize assessment results of student learning. A detailed description of AoL process was presented in five steps. Six basic experimental designs were discussed with reference to AoL implementation. Sixteen errors were briefed, and their effect on the dependent variable in AoL experiments was given. For readers' quick bite, results of the study were presented in two summary tables, one enlightens experiments and the effect of errors on them, the other about AoL error categories and outcome of errors. Also, observations of AoL reports of five business schools on seven factors related to AoL implementation were presented. Ended with a conclusion highlighting the use of experiments in AoL, errors which may potentially harm results and sampling methods to use. Statistical experimental designs and error control mechanisms are out of the scope of the present study.

Keywords: Assurance of learning, experiments, errors, sampling methods, closing the loop, rubrics, learning outcomes.

INTRODUCTION

Assurance of Learning (AoL) is an assertion of developing student attributes like student knowledge output and skill learning. The importance of AoL in student learning is due to the deployment of process assuring developing students soft and technical skills (French *et al*., 2012) also higher education institutions implement AoL to achieve desired outcomes in student learning (Leisa, 2007). Further AoL process involves achieving institutional mission, goals and objectives through student learning goals at the course level (Mcconnell *et al*., 2008). Institutions brand themselves with national and international accreditation, these bodies consider student learning the most important dimension in their evaluation (LaFleur *et al*., 2009), as such institutions mandate AoL design and implementation within the framework of these bodies with a moderate tailored operating process (Harper and Harder, 2009). As AoL is key to student learning, it demands the process to use appropriate scientific methods like experiments/errors/sampling methods. Rigorous AoL implementation needs the adoption of suitable experimental methods useful in generalizing the output of the process. Further in the course of using experiments, a variety of errors may distort student evaluation results. Hence the careful design of experiments is necessary to control errors within the scope of sampling methods. There is a wide research gap in the AoL literature related to the use of experiments/errors/sampling methods as McEwan (2015) revealed in student learning and assessment, there is a large portion of literature related to non-experimental approach indicating experiments are not widely used followed by errors and sampling methods. Ravenscroft *et al.* (1995) found the use of experimentation and controlling errors to generalize the results of student learning. Jackson *et al.* (2014) in their study had discussed the importance of using a suitable methodology, measurement and validating the results of AoL. Petronella and Riaan (2019) had used convenient simple random sampling to study a group of 48 students to obtain learning effectiveness. They failed to use experiment, instead used a single-shot student sample, which is used by the majority of research studies (McEwan, 2015) leading to non-generalization of results obtained. Given the above, this study gives an effort to discuss the concept of AOL implementation in general and acknowledge the role of experiments, errors and sampling methods.

METHODOLOGY

Assurance of learning

Assurance of Learning (AoL) is a systematic and scientific mechanism useful for the institutions of higher learning to ensure learning assurance among students (Baker *et al*., 2012). Blooms Taxonomy is the most reputed model followed for AoL implementation (Leila *et al*., 2009). Successful implementation of AoL is denoted as “Closing of loop”, which means students learning is effective. AoL is a faculty-driven process (Harper and Harder, 2009; Jackson *et al*., 2014; Kilpatrick *et al*., 2008), it follows probability sampling, where the probability of all faculty members and courses has equal chances of getting selected to AoL process. LaFleur *et al*. (2009) had found resistance from faculty members, they need to be motivated and supported by the management of the institution. In general, a simple random sampling is used to select courses/faculty members within each cycle of AoL to implement and report the results.

The first stage of AoL process starts by defining learning outcomes (LO’s) (Baker *et al*., 2012). LO’s are measurable variables written in the form of statements (Matt, 2009). LO’s are measured using a quantifiable mechanism known as a rubric. At the institution level, LO’s are drafted broadly which directly help in achieving the core values and mission of the institution. Leisa (2007), had discussed institutions' use of methodological approaches to achieve learning objectives for a specified set of skills. The institution’s purpose of the learning process is to train and input students on the core values, which are characteristics to be inculcated and built among students. The institution’s mission is the ultimate aim of the AoL which drives it. Institutional level LO’s imprint image on program-level learning objectives and course learning outcomes(CLO’s). CLOs are narrowed-down versions of institutional level LO’s (Kilpatrick *et al*., 2008). The logical flow - CLO’s achieve program learning objectives, in turn, they achieve LO’s, core values, and mission of the institution (Jackson *et al*., 2014).

The second stage involves scheduling activities of the AoL implementation cycle for a fixed period of time. In general, a cycle is defined as two years. AoL implementation and its effectiveness are measured with two cycles in four years. The implementation of AoL process is done by AoL committee, which is a group of faculty members drawn from programs of the institution. This committee is responsible for planning the AoL process, communication with programs, training the faculty members on AoL, coordinating with institution head-program heads-faculty members, implementation of AoL at the program level, collection and analysis of results, AoL report preparation and re-planning AoL process.

The third stage of the AoL process is an assessment of student performance which is rigorous and reflects the aims of higher learning (Leisa, 2007). Assessment methods selected for measuring performance for the AoL process should be of matured level involving ‘cognitive, affective and psychomotor’ (Leila *et al*., 2009). Multiple choice questions, true/false and short questions should be avoided (Messick, 1994). These questions involve answering by chance, which means under the condition of zero knowledge about the topic, the probability of selecting the correct answer is .5 for true/false and .25 in case of multiple-choice questions with 4 options. Scouller (1998), had found that multiple-choice questions are not that useful in student learning whereas essay-type questions are useful for deep learning and higher-order intellectual skills and development. Assessment methods like case solving, group/individual projects, research-based assignments, mathematical/statistical problems, simulation activity and others can be used to measure the student’s skills related to analytical, logical, reasoning, communication, problem-solving, coordination, ethical and managerial (Jackson *et al.*, 2014; Meuter *et al.*, 2009; Riggio *et al*., 2003; Kilpatrick *et al*., 2008; Matt, 2009). Petronella and Riaan (2019) had found that in reflective learning, the effectiveness of learning improves by practical experience. Mcconnell *et al.* (2008) found course-embedded assessment, which advocates localizing course-level assessments and then moving to program level for achieving better learning goals.

The fourth stage involves developing a measurement scale (Rubrics) used in student assessment. Rubrics are well-structured with equally distributed grade classes as column headings, assessment method components as row headings with each cell explaining the respective column-row. A caution in construction of rubrics ‘One possibility is to aim for scoring rubrics that are neither specific to the task nor generic to the construct but, rather, are in some middle ground reflective of the classes of tasks that the construct empirically generalizes or transfers to’ (Messick, 1994). In subjective assessment, rubrics act as a mediator between a faculty member and student. The rubric gives a clear and standardized explanation of what is poor and excellent performance (Kane *et al*., 2005), hence it reduces the conflict between faculty and student for grades to a large extent. Reddy (2011) concluded rubrics will help students to know their learning progress, teachers to know their teaching effectiveness and keep institutions, teachers and students to be on the same axis. Riggio *et al.* (2003) had investigated an alternative method known as AC (Assessment center) method to measure the student skill levels.

The final stage of AoL process ends with results, findings and recommendations (Baker *et al*., 2012). In the first cycle (first two years) a set of courses across programs are selected, AoL is implemented, results are measured and recommendations are recorded. In the second cycle(second two-year period) another set of courses across programs are selected and the same process is done. At the end of two cycles, a comprehensive AoL report is prepared informing whether learning outcomes are achieved known as “closing the loop” with findings and suggestions for future course of time. LaFleur *et al.* (2009) had found “Closing the loop” though achieved by AoL, will be successful in a program when all faculty members across the board make students practice the skill in the future course of time. Additionally, Harper and Harder (2009) in their study concluded that faculty members can close the loop successfully when they continuously keep track of curriculum development. Peer review team (PRT) evaluation of AoL and recommendations are also considered. AoL report prepared by institutional AoL committee is submitted to accreditation agency(like AACSB). During the site visit, PRT reviews the report and interacts with AoL committee and select faculty members to give its recommendations to be addressed in the following two AoL cycles. These recommendations give direction to AoL committee in planning. Different researches have discussed AoL process similar to the above description (French *et al.*, 2012).

Experiments

Experiments at institutions of learning involve obtaining proper information related to student learning (McEwan, 2015) with an acceptable accuracy range at a cost (McEwan, 2015) that does not exceed the value of the information. Experimental designs are categorized into two types. One; basic designs that consider the impact of only one independent variable at a time and; two, statistical designs such as multi-armed, factorial, multistage and blended can investigate two and more independent variables (Peck, 2020). The present paper covers only basic designs.

After only design (AOD): It involves manipulating the dependent variable and following a post-measurement. Treatment “X” is given to an experimental group, after some time, post-measurement “MA” is taken. This design does not control potential errors such as history, maturation, selection and mortality.

Before after design (BAD): It involves a pre-measurement, treatment and post-measurement. “MB” a pre-measurement is taken from the experimental group, after some time treatment “X” is given and post-measurement “MA” is taken. The difference between the two measurements (MA-MB) can be attributed to treatment. This design is subject to errors like history, maturation, pre-measurement, instrumentation, morality and interaction (Malhotra, 2016).

Before after with control design (BACD): It involves the addition of a control group. Majority of student learning experiments involves treatment and control group (McEwan, 2015). Randomly a group is selected termed as “treatment group”, “MB1” pre-measurement is taken, succeeding to it treatment “X” is given and post-measurement “MA1” is taken. Randomly another group is selected termed as “control group”, “MB2” a pre-measurement is taken, after some time without treatment post-measurement “MA2” is taken. (MB1-MA1) and (MB2-MA2) gives the difference between the pre and post-measurement of a dependent variable, the difference between ((MB1-MA1) - (MB2-MA2)) gives the effect of treatment “X” on a dependent variable (McEwan, 2015; Meuter *et al*., 2009). History, selection, mortality and measurement time errors may affect.

Simulated before-after design (SBAD): It is developed to control pre-measurement and interaction error in experiments dealing with attitudes and knowledge of human subjects. Randomly one group is selected termed as “control group”, “MB” a pre-measurement is taken, treatment is not given. Randomly another group is selected termed as “treatment group”, treatment ‘X’ is given and “MA” a post-measurement is taken. The difference between the two groups gives the actual change in the dependent variable pertaining to the treatment variable or independent variable. Ravenscroft *et al.* (1995) used a similar design where they had taken pre-measurement before finally placing the sample elements into the experimental groups. (MA-MB) gives the difference between the pre and post measurement of the dependent variable. This design may be affected by history, selection, mortality and measurement timing.

After only with control design (AOCD): It does not involve pre-measurement, avoiding errors related to it, and also reducing the cost incurred due to pre-measurement. Randomly a group is selected termed as “treatment group”, treatment “X” is given and “MA1” a post-measurement is taken. Randomly another group is selected termed as “control group”, “MA2” a post-measurement is taken (Ryals and Wilson, 2005). This design cannot control selection error (Malhotra, 2016) where when selecting two groups randomly might have an unequal attitude/behavior about the variable of interest(dependent variable); and surrogate information, reactive error among others.

Solomon four-group design (SFGD): It is also known as four group six study design. This design is a blend of before after with control design and after only with control design. It controls all other errors except measurement timing, selection and reactive errors.

Errors in experiments

There are potential errors that can affect experimental research designs involved in the manipulation of a dependent variable(s) by the independent variable(s) (Malhotra, 2016), also applicable to AoL experiments. Errors can be avoided; it is the responsibility and efficient practices of the experimenter. The case of un-avoidable errors is outside the scope of the experimenter but can give their best.

Surrogate information error (SIE) – caused by a variation between the information needed to solve the problem and the information sought. Measurement error (ME) – difference between the needed information and generation by the measurement process. It is possible to garner information that is different from what is being sought. Experimental error (EE) – experiments are designed to measure the effect of independent variable/s on a dependent variable, this occurs when the effect of the experimental situation is measured rather than the effect of an independent variable. Population-specific error (PSE) – selecting an unsuitable population for an experiment. Frame error (FE) – Selection of inappropriate sample units from a population with the condition being each sample unit to be selected only once from the population and suitable sample categories to be included, lest results in this error. Sampling error (SE) – possibility of selecting a non-representative sample by using a probability sampling method. McEwan (2015) in his study selected sample students randomly giving the chance of sampling error, other errors were covered with an experimental design consisting of treatment and control groups. Non-response error (NRE) – inability to contact all members of sample results in non-response from some samples and for some questions in the measurement instrument. Pre-measurement error (PME) – effect of initial measurement causes changes in the dependent variable. Interaction error (IE) – sample elements after premeasurement interact with extraneous variables leading to effects on the dependent variable in an increased or decreased manner. Maturation error (MAE) – when the duration of experimentation is long, sample respondent’s personal behavior/motivation between pre and post-measurement might change affecting the dependent variable. LaFleur *et al.* (2009) had collected student learning data for 3 years, such a long duration affects the motive of sample elements to a large extent. Similarly, Riggio *et al*. (2003) in their longitudinal studies related to student learning effectiveness measurement faced a lot of changes such as change of capstone course, lack of experimental funding and others. History error (HE) – when sample elements had interacted with variables or events in past or between pre and post-measurement, also which are out of experiments scope can cause an effect on the dependent variable. Instrumentation error (INE) – between pre and post-measurement both experimenter and respondent may not continue with the same motivation, may become more skilled or perform better due to treatments or external variables. Selection error (SE) – when a sample involves several groups, the possibility of one group participating with high morale in the experiment leads to a higher effect on the dependent variable. In a study by Cai *et al.* (2020) student learning experiment after only with control design with two random groups resulted in selection error, they did not report any measure in controlling this error. Mortality error (MOE) – when a large sample is involved in the experiment, it may be difficult to keep the continuity of respondent’s morale due to which some of them quit. Reactive error (RE) – as experiments are artificial, both experimenter and respondent may behave fully conscious towards treatments and effect dependent variables. Measurement Timing error (MTE) – variables will have a short and long-term effect in experiments. When pre and post-measurement are planned at an inappropriate time, may have an inaccurate effect of treatment on the dependent variable. Ravenscroft *et al.* (1995) designed a simulated before-after design, using a small sample pre-measurement and post-measurement were taken and tried to control a majority of the errors, except for errors like MTE, RE and PME.

Sampling methods

Sampling methods are categorized as one; non-random or judgement sampling, in which the researcher uses his experience to identify sample elements (Aaker *et al.*, 2013). Judgement sampling faces the disadvantage of having limited use only by experts, hence its application in experiments is very limited. Two; random or probability sampling (Malhotra, 2016). In random sampling, all the items from the population have an equal chance of being chosen for the sample. There are four random sampling techniques as discussed by Aaker *et al.* (2013) which are often used in experiments :

Simple random sampling (SRS): This allows each possible sample item or element to have an equal probability of being picked up from a given population. If there are x1, x2, …….xn elements/items in a population, then each element has an equal probability 'x/n' of getting selected into the sample. The majority of research studies used simple random sampling (Reddy, 2011; French *et al*., 2012; Cai *et al.*, 2020; LaFleur *et al*., 2009; Leila *et al.*, 2009; Baker *et al.*, 2012). Except for few studies which used the whole population (Riggio *et al*., 2003).

Systematic random sampling (SYRS): The elements are selected from the population at a uniform interval that is measured in time, order or space. If there are x1, x2, …….xn elements/items in a population, then elements are picked into the sample by time interval (every 5 minutes, 10 minutes…); order interval (every 5th person, 10th person…..) and space interval (every 50 meters, 100 meters……).

Stratified random sampling (STRS): The population is divided into relatively homogeneous groups called "strata". Samples are selected at random from each "stratum". If there are x1, x2, …….xn elements/items in an population. Proportion "P" of this population is distributed among groups/strata on a certain factor/s "F". The total sample size "n" is distributed based on "P" for groups/strata, which means a specified number of elements corresponding to the proportion of the "stratum" in the population.

Cluster random sampling (CLRS): The population is divided into relatively non-homogeneous groups called "clusters". If there are x1, x2, …….xn elements/items in a population, samples are selected at random from select "clusters" suitable for a particular study.

RESULTS AND DISCUSSION

Analysis of experiments, errors and sampling methods in AoL

This section presents an analysis of experiments, errors, sampling methods useful in AoL process implementation. For achieving scientific generalizable assurance in student learning, experimentation of teaching methods and delivery is important. Experimentation helps an institution to know which teaching method and delivery mechanism give effective student learning.

After only design (AOD) analyzing for AoL implementation - a random group of students (experimental course) is selected, treatment "X" (a skill practiced by students), after a time gap skill is measured "MA". The problem with this design, it does not involve pre-measurement "MB" which makes it difficult to understand what was the skill level of students before the treatment, hence pre and post a comparison of student skill level is not possible. Additionally, prior student skill level before taking them into experiment leads to history error, and students who drop the course; who are denied due to shortage of attendance leads to mortality error, and those who lose motivation due to pressure of course overload leads to maturation error; these errors will affect post measurement.

Before after design (BAD) analyzing for AoL implementation - A random group of students (experimental course) is selected, pre-measurement "MB" is taken. after a time-gap treatment "X" (a skill practiced by students), post-measurement "MA" is taken. The difference between MB and MA is attributed to X. Similar to the last experiment; history, mortality, maturation, will affect the measurement. Alternately some errors improve the effectiveness of AoL implementation like pre-measurement error through which students become alert due to MB and seriously put effort to better in MA. Instrumentation error in which the experimenter(teacher) and respondent (student) gain expertise through MB, practice the skill and perform better in MA.

Before after with control design (BACD) analyzing for AoL implementation - A random group of students (experimental course termed as treatment group) is selected, pre-measurement "MB1" is taken. After which treatment "X" (a skill is practiced by students), post-measurement "MA1" is taken. Randomly another group of students(termed as a control group) is selected, pre-measurement "MB2" is taken. after a time-gap post-measurement, "MA2" is taken. The difference between MB1 and MA1 gives the effect of skill practice and the difference between MB2 and MA2 gives the effect without skill practice. Meuter *et al*. (2009) used a similar design and found teaching effectiveness improvement was reported in the treatment group. Mortality, maturation errors will affect this measurement. Alternately history error is addressed by pre-measurement. Measurement and instrumentation errors improve the effectiveness of AoL implementation. Messick (1994) had suggested using controls in student performance measurement experiments to offset the effects of certain errors.

Simulated before-after design (SBAD) analyzing for AoL implementation - A random group of students (experimental course termed as the control group) is selected, pre-measurement "MB" is taken. Randomly another group of students (termed as treatment group) is selected, treatment “X” (a skill is practiced by students) and post-measurement “MA” is taken. The difference between MB and MA gives the effect of skill practice. Mortality, maturation errors will affect this measurement whereas history error is taken care of by the control group, measurement and interaction errors are controlled due to the selection of two different random groups for MB and MA. A study by Ravenscroft *et al.* (1995) using accounting students randomly selected found student learning to be effective.

After only with control design (AOCD) analyzing for AoL implementation - A random group of students(experimental course termed as treatment group) is selected, treatment “X” (a skill is practiced by students) and post-measurement “MA1” is taken. Randomly another group of students (experimental course termed as a control group) is selected, post-measurement “MA2” is taken. The difference between MA1 and MA2 gives the effect of skill practice (Cai *et al.*, 2020). Mortality, maturation errors will affect this measurement whereas history error is taken care of by control group measurement (Ryals and Wilson, 2005). Selection error can affect if there is an imbalance in student numbers between two random groups.

Solomon four-group design (SFGD) analyzing for AoL implementation - (I) A random group of students (experimental course one termed as treatment group) is selected, pre-measurement “MB1” is taken. after which treatment “X” (a skill is practiced by students), post-measurement “MA1” is taken. (II) Randomly another group of students (termed as the control group) is selected, pre-measurement “MB2” is taken. after a time-gap post-measurement, “MA2” is taken. (III) A random group of students(termed as treatment group) is selected, treatment “X” (skill is practiced by students) and post-measurement “MA1” is taken. (IV) Randomly another group of students (termed as the control group) is selected, post-measurement “MA2” is taken.

The difference between (I) & (III), (II) & (IV) gives the effect of skill practice. Adverse to literature, reactive error causes a positive effect improving the effectiveness of AoL implementation. Mortality, maturation errors will affect this measurement. Alternately history error is addressed by pre-measurement. Measurement and instrumentation errors improve the effectiveness of AoL implementation. Mortality, maturation errors will affect this measurement whereas history error is taken care of by control group measurement. Selection error can affect if there is an imbalance in student numbers between two random groups.

From the above analysis and Table 1, it can opine that all experiments can be successfully conducted in AoL. All four sampling techniques can be used, but the AoL experiments discussed only cover simple and systematic random sampling. Interestingly all errors do not cause negative effect, some leave positive effect, some are addressed, some cannot be addressed as they are out of the scope of experiments, and some errors are not applicable.

This study tabulated outcomes and categorized experimental errors in AoL implementation shown in Table 2, as; AoL sampling errors (AoL-SE) - population-specific error, frame error, sampling error, non-response error. AoL rubric errors (AoL-RE) - surrogate information error, measurement error, experimental error. AoL implementation errors (AoL-IE) - pre-measurement error, interaction error, maturation error, history error, instrumentation error, selection error, mortality error, reactive error, measurement timing error.

Experiments used in AoL need to disclose errors and sampling methods used. A large number of studies either lack or do not give importance to disclose them McEwan (2015). Cai *et al.* (2020) involved two groups of students, where one group was given a guidance manual to finish the task and another group was not given; compiled results show the difference between these groups, it lacked disclosure of experiment group and control group, also possible errors and efforts taken to reduce the effect of errors were not discussed. In another study by Meuter *et al.* (2009) with an objective of experimenting with standardization of curriculum across serval courses, implemented AoL processes were monitored and measured. Both these studies lacked clarity about the experimentation process to the reader. Alternatively, McEwan (2015), discussed several studies which involved experimentation with treatments as grants, nutritional, information, management policy, instructional material and performance incentives. His study had found that all these treatments affected student learning. Ravenscroft *et al.* (1995) had selected two groups of students, one experimental group and another control group for measuring the skill performance level. Before selecting the students into these groups, to avoid pre-measurement errors, team exercises were conducted, based on the scores from these exercises students were selected into experimental and control groups. The experimental group’s skill performance was measured using a cooperative grading system and a traditional grading system for the control group. Baring reactive and measurement timing errors this experimentation addressed all other errors.

Assurance of learning (AoL) at five business schools

Five business schools were randomly selected with different years of AoL implementation.

These five schools were selected based on the criteria of schools AoL report accessed by date 7th January 2021.

Table 1. Effect of errors on AoL experiments.

→ Experimental designs / Experimental Errors ↓	AOD	BAD	BACD	SBAD	AOCD	SFGD
SIE	(-)	AD	AD	AD	(-)	AD
ME	NPA	NPA	NPA	NPA	NPA	NPA
EE	NPA	NPA	NPA	NPA	NPA	NPA
PSE	NPA	NPA	NPA	NPA	NPA	NPA
FE	NPA	NPA	NPA	NPA	NPA	NPA
SE	NPA	NPA	NPA	NPA	NPA	NPA
NRE	NPA	NPA	NPA	NPA	NPA	NPA
PME	NA	(+)	(+)	(+)	NA	(+)
IE	NA	(+)	(+)	(+)	NA	(+)
MAE	(+)	(+)	(+)	(+)	(+)	(+)
HE	AD	(-)	(-)	(-)	AD	(-)
INE	(+)	(+)	(+)	(+)	(+)	(+)
SE	(-)	(-)	(-)	(-)	(-)	(-)
MOE	(-)	(-)	(-)	(-)	(-)	(-)
RE	(+)	(+)	(+)	(+)	(+)	(+)
MTE	(-)	(-)	(-)	(-)	(-)	(-)
AD – AoL experiment addresses the error	(-) – error will cause a negative effect on AoL experiment dependent variable	(+) – error will cause a positive effect on AoL experiment dependent variable	NPA – It is not possible to address the error by AoL experiment		NA – error is not applicable to AoL experiment	

Table 3 Presents AoL report of these schools on eight factors: learning goals/objectives, cohort courses, AoL cycle/plan, methodology (experiments, the effect of errors and sampling methods use, and others), AoL committee, AoL process, assessment/results, recommendations, closing the loop.

Observation of schools AoL reports reveal information related to a majority of dimensions were discussed except for two dimensions by two schools, but the methodology was not addressed and reported by any of the schools. Methodology in AoL implementation refers to sampling methods used for selecting cohorts, experiments used to test the cohorts, mechanism of controlling the errors and their effect. As discussed earlier using the methodology for AoL implementation is key for the generalization of results. Reports indicate students achieved the required skill level and the method of skill training is successful across the schools' programs leading to closing the learning loop.

LIMITATION AND FUTURE RESEARCH

This study considered basic experimental designs which accommodate simple and systematic random sampling methods. Extension studies can pursue statistical experimental designs that allow evaluating effect of more than one independent variable at a time. Designs like randomized blocks design(RBD), Latin square design, the factorial design have scope to accommodate cluster and stratified sampling methods. The study discovered errors causing positive, negative, not possible to address or not applicable. This study did not address how errors can be avoided while conducting experiments, this can be carried by future extension studies.

CONCLUSION

Assurance of Learning (AoL) when implemented without a scientific approach leads to ad hoc outputs that cannot be generalized. To implement AoL scientifically, appropriate experiments and sampling methods have to be used for avoiding errors. This research highlights six basic experiments; after only design (AOD), before-after design (BAD), before after with control design (BACD), simulated before-after design (SBAD), after only with control design (AOCD), Solomon four-group design

Table 2. Outcome related to AoL experiment error categories.

AoL Experiment → errors categories / Outcome ↓	AoL sampling errors (AoL-SE)	AoL rubric errors (AoL-RE)	AoL implementation errors (AoL-IE)
AD – AoL experiment addresses the error	--	Surrogate information error	--
(-) – error will cause negative effect on AoL experiments dependent variable	--	Surrogate information error	History error, Selection error, Mortality error, Reactive error, Measurement Timing error
(+) – error will cause positive effect on AoL experiments dependent variable	--		Pre-measurement error, Interaction error, Maturation error, Instrumentation error,
NPA – It is not possible to address the error by AoL experiment	Population specific error, Frame error, Sampling error, Non-response error	Measurement error, Experimental error	--
NA – error is not applicable to the AoL experiment	--	--	Pre-measurement error

Table 3. AoL reports observation.

Schools → / Factors ↓	USM AoL report 2018 (USM School of Business, 2018)	RU AoL report 2011-12 (RU College of Business and Economics, 2011-12)	WKU AoL report 2017 (Gordon Ford College of Business, 2017)	UTSA AoL report 2018 (San Antonio College of Business, 2018)	KSU SER 2016
Learning goals/objectives	√	√	√	√	√
AoL committee	√	×	√	√	√
AoL cycle/plan	×	×	√	√	√
AoL process	×	×	√	√	√
Cohort courses	√	√	√	√	√
Methodology (experiments, effect of errors and sampling methods use) and others	×	×	×	×	×
Assessment/results	√	√	√	√	√
Recommendations	√	√	√	√	√
Closing the loop	√	√	√	√	√

- USM School of Business (UNIVERSITY OF SOUTHERN MAINE-USM); Davis College of Business and Economics (RADFORD UNIVERSITY-RU); Gordon Ford College of Business (WESTERN KENTUCKY UNIVERSITY-WKU); UTSA College of Business (THE UNIVERSITY OF TEXAS AT SAN ANTONIO-UTSA); College of Business Administration (KING SAUD UNIVERSITY- KSU).
- SER – Self-evaluation report.

(SFGD). Analysis section presented how these experiments and sampling methods can be used for AoL implementation; what is the possible positive and negative effect of errors. In the literature, there is evidence only a simple and systematic random sampling technique is being used in basic experiments. Generally, in research, errors negatively affect experiments, but with regards to AoL implementation, experimentation errors have both negative and positive effects. This paper developed table 1 with columns as experiments and rows indicating errors and segmented the effect of errors on experiments as 1. AD : (AoL experiment addresses the error); 2. (-) : (error will cause negative effect on AoL experiments dependent variable); 3. (+) : (error will cause positive effect on AoL experiments dependent variable); 4. NPA : (It is not possible to address the error by AoL experiment); 5. NA: (the error is not applicable to the AoL experiment). Table 1 helps the reader at a glance, especially the AoL implementors to understand the error effect experiment-wise. Table 2 was developed with columns categorized as errors customized to AoL and rows indicating the segmented effect of errors on experiments. Table 2 helps in understanding the relationship of specific experimental error placed in cells to the AoL error category and segmented effect. This research is the potential in giving the reader a scientific view of AoL implementation in relation to experiments, errors and sampling methods. It also tried to give abbreviations for experiments and errors which makes it easy to remember.

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