Active Learning among University STEM Teachers: Familiarity, Confidence and Current Use

by
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Abstract

The Ministry of Education, Culture, Sports, Science and Technology (MEXT) has emphasized active learning (AL) as one means to improve higher education. MEXT has not, however, presented educators with a clear definition of AL. This has lack of clarity has had the effect of creating a situation where university educators have neither a clear conception of AL nor sufficient understanding of how to implement AL in their courses. While this an issue for faculty members in all disciplines, it is likely a more pressing one for university educators in STEM fields. This study sought to elucidate the current situation of AL implementation among university STEM teachers by reporting results from a pilot survey of faculty members at the researchers' institution. Responses showed that while there is a reasonable understanding of basic AL principles, and that faculty members are fairly confident in their abilities to implement AL, when examined in relation to participation in FD events, substantial differences in understanding in confidence and understanding appeared among educators. The most commonly reported means of using AL in the classroom were group-based approaches, but together with issues in assessing learning in AL, organizing groups was the most commonly reported issue. The implications of these findings for the enhancement of future faculty development activities is discussed.

Key Words: Active learning, STEM, Faculty development,

1. Introduction

Over the past decade The Ministry of Education, Culture, Sports, Science and Technology (MEXT) has emphasized active learning (AL) as one means to improve higher education and help learners develop the skills they need to compete in a globalizing economy (e.g., MEXT 2012, 2014). In the wake of this policy shift, there has been a marked increase in the number of publications focused on AL, exemplified by the increase in the number of articles found in the CiNii database, from five articles in 2008 to 968 in 2017 (Yamauchi, 2018). These trends have created pressures on universities to implement AL throughout their curricula (Jones & Palmer, 2017). Carrying out these reforms in practice has been a challenge for many universities however, as AL often has been incorporated into curriculum without educators having a full understanding of its significance and characteristics (Nakai, 2015). While this an issue for faculty members in all disciplines, it is likely a more pressing one for university educators in STEM fields, who tend to be subject-area specialists rather than pedagogical specialists, and who therefore may lack a clear conception of active

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learning or how to implement AL in their courses. For this reason, despite MEXT's push for more active learning in university curricula, the actual implementation of active learning among STEM educators may remain rather limited. Moreover, even this limited implementation has been interrupted by the sudden transition to online classes due to the Coronavirus pandemic. This study seeks to clarify the current situation regarding the implementation of AL among university STEM teachers by reporting results from a pilot survey administered to faculty members at the authors' university.

2. Literature Review

Bonwell and Eison (1991) define active learning (AL) as "anything that involves students in doing things and thinking about the things they are doing," (p. 2). As part of their reforms to transform undergraduate education, MEXT has called for a "transition to active learning" in university-level education (MEXT, 2014, translation by the authors). As noted by Ito (2017), MEXT's own characterization of AL resembles that of Bonwell and Eison, "unlike traditional didactic lectures, AL is a type of learning where students actively learn through various instructional methods such as collaborative learning (CL) and problem/project-based learning (PBL) to develop generic skills," (p. 2). Ito goes on to point out, however, that while describing these generic skills as "cognitive, ethical, social, and life skills," (p. 2), MEXT has not further refined or clarified its characterization of AL, and for this reason, the actual definition of AL in the context of the Japanese educational system remains unclear. This lack of clarity has had the effect of creating a situation where university educators have neither a clear conception of AL (Ito, 2017), nor sufficient understanding of how to implement AL in their courses (Nakai, 2015).

In their efforts to respond to the pressure to incorporate AL into their courses, many university educators see the adoption of more student-centered methodologies, primarily in the form of collaborative learning and task-based learning, as equivalent to the implementation of AL, and give little consideration to how AL should be utilized in promoting learning (Tsuchimochi, 2016). Mori (2018) makes the point that for learners and educators to realize the benefits of AL requires careful preparation as well as consideration of learning objectives and outcomes, rather than the implementation of AL techniques, such as group-based learning approaches or task-based learning. In other words, in attempting to comply with MEXT's directive, the incorporation of AL into university curricula may have more often than not focused on "doing things," that is, the "active" part of AL, while the "learning" part, or "thinking about the things they are doing," may have been unintentionally disregarded.

The purpose of active learning is not simply to get students up and moving, or doing something other than just listening to a lecture, but to engage them in learning, and thereby, to engage them in higher-order cognitive activity. When effectively employed in the classroom, AL can "provide opportunities for learners to think critically about content through a range of activities that help prepare learners for the challenges of professional situations," (Croker & Kamegai, 2017, p. 65).

The importance of effectively implementing AL is especially relevant in the STEM disciplines. A recent meta-analysis of 225 studies conducted by Freeman et al. (2014) found that the use of AL in university STEM courses can improve student outcomes over a more traditional lecture style by 0.3 points (or half a letter grade, e.g., from a B to B+), and reduce failure rates from 33.8% to 21.8%. While this is a welcome finding, the results from an earlier study by Andrews et al. (2011) must be kept in mind. This study makes the important point that students' do not necessarily learn better simply because the instructor employs AL techniques in their courses. To gain the benefits of active learning it is important that the instructor employ the techniques effectively. According to Andrews et al., the effective use of AL, "requires skills, expertise, and classroom norms that are

fundamentally different from those used in traditional lectures," (p. 403), and this implies that not only do STEM teachers need to reconsider the methods and techniques they use in their classrooms, but also that they require support from their institutions and sufficient training to make the implementation of AL successful. Nakai (2015) underlines this point, "Active learning is an educational approach, and therefore it depends on the faculty to make it an effective one. For this reason, faculty development (FD) is important," (p. 11, translation by the authors).

This study seeks to better understand the current situation of AL implementation among university STEM educators by investigating how familiar these educators are with AL, how well they understand its basic principles and how much FD they have taken part in. It further seeks to clarify how confident faculty members are in their ability to implement AL, how they are using AL in their courses, and what issues they encounter when using doing so. In addition, there has been a particular emphasis on AL-focused FD at the university where this study took place as part of the university's participation in the Acceleration Program for University Education Rebuilding (AP) program (Theme I: Active Learning), and so this paper will also examine the influence of FD on the aforementioned aspects. The study is framed by the following research questions:

1) How familiar are faculty members with AL?

2) How confident do they feel in their ability to use AL in their classrooms?

3) Are faculty members using AL in their courses, in what ways, and what issues do they face when doing so?

3. Methodology

The present study was designed as an exploratory pilot survey aimed at uncovering the current situation of AL implementation among university educators. The survey instrument employed in this study was adapted from that used by Croker & Kamegai (2017, 2018; Kamegai & Croker, 2018). The original survey comprised 51 items (45 closed-response, and six open-response) and was designed for use with Japanese high school English teachers. This instrument asked respondents to provide information on an array of topics related to their use and understanding of AL, including their familiarity with AL, how often and in what ways they used AL in the classroom, their perceptions of AL in terms of their ability to implement it and as an effective teaching method, and their definition of AL.

In adapting the survey instrument for the present study, the authors focused on the following five areas: (1) faculty members' familiarity with AL, including the number of FD sessions they had attended; (2) their conception of AL and their understanding of its basic principles; (3) how confident faculty members felt in their ability to: devise classes based on AL, to prepare AL activities; organize pair and group work; employ PBL/TBL; and assess learning in AL; (4) their use of AL in the classroom (taking the 2019 academic year as an example), the ways they used AL in these classes, and the issues they faced in doing this; (5) their use of AL in their online courses (taking the first-term of the 2020 academic year as an example), the ways they used AL in these course, and the issues they faced in doing this. From the 51 questions in the original survey, the total number of questions was reduced to 17 (12 closed-response and five open-response).

The survey was created using Google forms, and a link to the survey was sent out in an email to all faculty members in July of 2020 using a faculty-wide email address. The email explained the purpose of the survey and asked for volunteers to participate, and thus the sample in this study is a convenience sample, rather than a truly random and representative one. Faculty members were given two weeks to complete the survey, and a follow-up email was sent one week before the close of this period. A total of 52 faculty members responded to the email by taking the survey. More detailed information on the

participants is given in the Results section below.

The 12 closed-response items from the survey (5 Likert-scale, 3 yes-no, 3 multiple-choice, and 1 short-answer) were summarized using descriptive statistics. In addition to presenting results from the faculty members taken as a whole, respondents were separated into three groups based on the number of FD sessions they had attended — Group 1 (n = 10), non-attendees of FD events; Group 2 (n = 33), attendees of between 1 and 5 FD events; and, Group 3 (n = 8), attendees of more than 5 FD events— in order to investigate the influence of FD on faculty members' familiarity with, confidence in using and current use of AL. To investigate differences in the patterns of responses between these groups, Kruskal-Wallis and Mann-Whitney U tests were used.

Open-ended items were analyzed using a data-driven coding approach (Gibbs, 2007). The data was initially coded by both authors independently. Multiple rounds of coding were undertaken to maximize intra-coder reliability (Revesz, 2012). The independent coding results were compared and a single set of codes was agreed upon by both authors.

As the survey, even in its shortened exploratory form, examines a range of educator experiences with AL, the results of the survey will be reported in several papers. This paper has three aims: (1) to clarify faculty members' familiarity with AL (as measured by their participation in FD events, the number of events they have attended and their self-reported understanding of the basic principles of AL); (2) to understand their degree of confidence in using AL (as measured by how confident faculty members feel in their ability to devise classes based on AL, to prepare AL activities, to organize pair and group work, to employ PBL/TBL, and to assess learning in AL); and, (3) to summarize their use of AL under normal circumstances (as measured by their use or non-use of AL during the 2019 academic year), with an eye towards the relationship between these aspects and participation in FD. For this reason, it will focus primarily on responses related to these aspects, and present only a summary of the ways faculty members use AL and the issues they face in normal circumstances in order to give context to these aspects.

As outlined above, faculty members' conception of AL is an important factor in how they implement AL, and a more detailed investigation of the relationship between these two factors, as well as the issues faculty members' face in implementing AL, focusing on thicker descriptions of the data sets will be reported in a forthcoming paper by the authors. Furthermore, as the sudden transition to an online environment in the first-term of 2020 also introduced a number of factors (such as unfamiliarity with teaching online and new forms of ICT) faculty members use of AL and the issues they faced in this environment will be examined in a further paper.

4. Results

4.1 Participant Data

Of the 244 faculty members teaching at the authors' university, 52 responded to the email and completed the survey, a response rate of 21.3%. This response rate was similar to that of 29% reported in Patrick et al. (2016) in a study examining perceptions of AL among STEM faculty at large American public university.

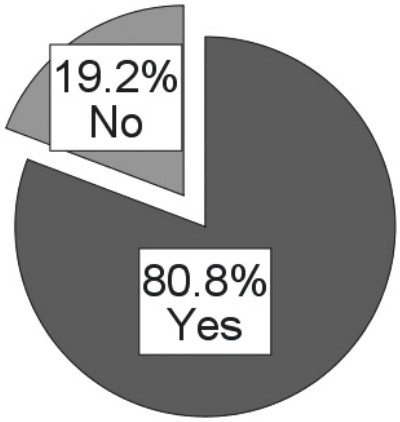
The first item on the survey concerned respondents' university teaching experience. The answers reported by participants ranged from 1 to 44 years, with a mean of 15.26 years, and a median value of 12 years. There was at least one respondent from each 13 of the departments and centers within the university, with the Center for Education and Innovation and the Department of Pharmaceutical Sciences having the largest number of respondents (8 each).

4.2 Faculty Members' Familiarity with AL

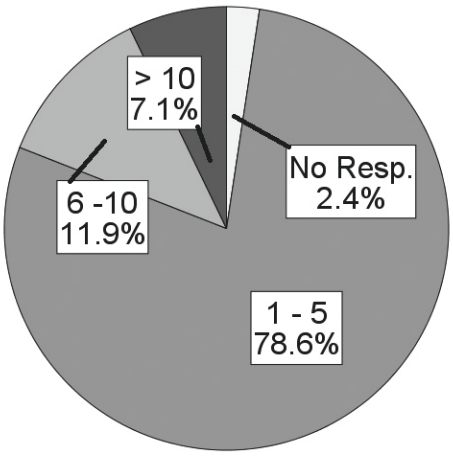
For university faculty, FD activities serve as the primary means by which new pedagogical methods are introduced. These activities most often take the form of the workshops or seminars. As one measure of faculty members' familiarity with AL, respondents

were asked whether or not they had attended an AL focused FD session, and if so, how many they had attended (1 to 5, 6 to 10, or more than 10). In addition, respondents were asked how well they understood the basic principles of AL. Replies to this question were on a 4-point Likert-scale, with 1 semantically anchored to *I don't understand AL well,* and 4 to *I have a good understanding of active learning.*

As shown in Figure 1a, among the 52 respondents,



a)



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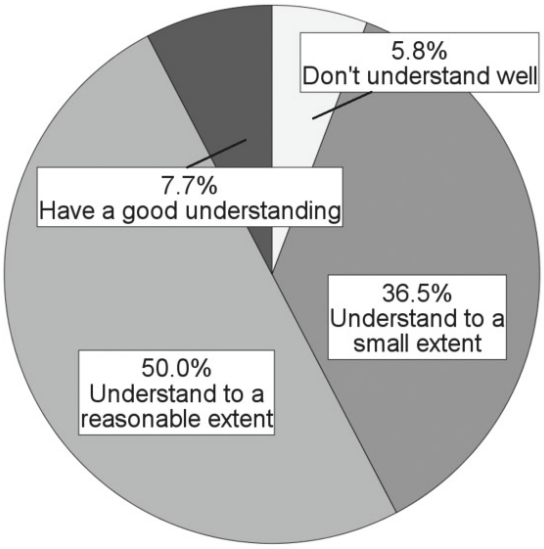

c)

Figure 1. a) Percent of faculty members who have taken part in AL-focused FD activities. (n = 52)
b) Number of FD sessions attended. (n = 42)
c) Understanding of basic AL principles. (n = 52)

42 respondents (80.8%) had taken part in AL-focused FD, while ten (19.2%) had not. This high rate of participation is not surprising given the emphasis the university has placed on AL-focused FD as part of the AP Program. Nonetheless, it is important to note that almost 20% of the faculty members (10 of 52) who responded to the survey have not taken part in such training. This points to need for a better understanding of the reasons why they haven't taken part and, based on that understanding, the possible need for further FD, which might take a form other than traditional in-person workshops and seminars.

Among the 42 faculty members who have taken part in AL-focused FD, the large majority, 33, have attended between one and five FD sessions (Figure 1b). Much smaller numbers have attended between 6 and 10 (5), and 10 (3). One respondent did not answer this question.

Figure 1c shows that when taken as a whole (n = 52), a majority of faculty members expressed either

a reasonable or a good understanding of basic AL principles (26 and 4 respondents, respectively). Nineteen respondents self-reported that they understood these principles to a small extent, while three reported that they did not understand the basic principles of AL well.

As mentioned above, one aim of this study was to investigate the influence of FD on faculty members' perceptions of AL, and thus, respondents were broken down into three groups based on the number of FD sessions they had attended: Group 1 (n = 10), non-attendees of FD events; Group 2 (n = 33), attendees of between 1 and 5 FD events; and, Group 3 (n = 8), attendees of more than 5 FD events. Responses of the three groups in regard to self-reported understanding of basic AL principles are summarized in Table 1.

Table 1. Understanding of basic AL principles

Degree of Understanding	**Group 1** (n = 10)	**Group 2** (n = 33)	**Group 3** (n = 8)
Don't understand well	1 (10.0%)	2 (6.1%)	0 (10.0%)
Understand to a small extent	5 (50.0%)	13 (39.4%)	1 (12.5%)
Understand to a reasonable extent	4 (40.0%)	17 (51.5%)	4 (50.0%)
Have a good understanding	0 (0.0%)	1 (3.0%)	3 (37.5%)
M	2.00	2.52	3.52
SD	.657	.667	.707
Md	2.00	3.00	3.00

Note: Group 1: attended 0 FD events
Group 2: attended from 1 to 5 FD events
Group 3: attended more than 5 FD events

Here differences between the members of each groups and the faculty members taken as a whole become apparent. An interesting pattern in responses between the three groups appears in the table, with an almost mirror image in the distribution of responses between Group 1 and Group 3. The 60% of respondents in Group 1 reported a limited understanding of basic AL principles, while over 80% of respondents in Group 3 reported at least a reasonable understanding. While responses from Group 2 were more evenly split, nonetheless, a majority of this group reported that they possessed at least a reasonable understanding of the basic principles.

In order to more fully examine these apparent trends, scores between the three groups were compared using a Kruskal-Wallis Test. The test revealed a significant difference in self-reported understanding across the three groups, χ^2 (2, n = 51) = 7.76, p = .021. Mann-Whitney U tests were used to follow-up this finding. As three tests were conducted, a Bonferroni correction was applied, and therefore all effects are reported at a .0167 level of significance. The tests revealed no significant difference in self-reported understanding between Group 1 and Group 2 (U = 137.5, z = -.878, p = .380), however, a significant difference was found between Group 3 and Group 1 (U = 14.5, z = -2.43, p = .015), with a large effect size (r = .57; Cohen, 1988), as well as between Group 3 and Group 2 (U = 64, z = -2.46, p = .014), with a medium effect size (r = .38; Cohen, 1988).

4.3 Faculty Members' Confidence in Using AL

Respondents were asked to rate their degree of confidence in their ability to: devise classes based on AL (Item 1); prepare AL activities (Item 2); organize pair and group work (Item 3); employ PBL/TBL (Item 4); and, assess learning in AL (Item 5). Each of the items were rated on a 4-point Likert scale (1 = *I don't think so at all*; 2 = *I don't think so*; 3 = *I think so*; 4 = *I strongly think so*), with higher scores indicating a higher degree of confidence (See Table 2). Participants were also given an option to respond with *I can't judge my ability.* A small number of respondents chose this option for each of these items: 2 respondents for Item 1, 1 for Item 2, 2 for Item 3 (in addition, 1 respondent did not answer this item), 2 for Item 4, and 3 for Item 5 (with 2 respondents not answering this item). These responses were not included in the analyses reported below, but the significance of choosing this option will be

discussed. A summary of responses for these five items from faculty members taken as a whole are presented in Table 2.

Table 2. Faculty members' degree of confidence in their ability to implement AL

Degree of confidence in	M	SD
Devising classes	2.60 [1]	0.70
Preparing activities	2.82 [2]	0.65
Organizing groups	2.78 [3]	0.69
Using TBL/PBL	2.60 [4]	0.67
Assessing learning	2.53 [5]	0.69

[1] $n = 50$ [2] $n = 51$ [3] $n = 49$ [4] $n = 50$ [5] $n = 47$

Overall, faculty members expressed a moderately strong degree of confidence in their abilities in these five areas, with the highest degree of confidence in their ability to prepare AL activities ($M = 2.82$, $SD = .65$). As noted above, only one faculty member responded with *I can't judge my ability* on this item. Faculty members expressed the lowest degree of confidence in their ability to assess AL ($M = 2.53$, $SD = .69$), and in addition, there were three responses of *I can't judge my ability* on this item, as well as two non-responses. Taken together, this suggests that faculty members perceive a higher degree of difficulty in assessing AL, and that therefore this is an area that could be addressed in future FD events.

Table 3 presents responses for these five items when faculty members are separated into the three groups based on participation in FD. The item with the lowest mean score was Item 1 ($M = 2.30$, $SD = .68$ [Group 1]), and that with the highest score was Item 2 ($M = 3.53$, $SD = .54$ [Group 3]). There is an evident trend in the scores, with an increase in the means for each item as one moves across the table from Group 1 to Group 3. This trend is similar to that found above in regards to faculty members' degree of understanding, with respondents who took part in a greater number of FD events reporting a higher degree of confidence in all five areas.

Table 3. Degree of confidence in ability to implement AL (by groups)

Aspect of AL	Group 1 ($n = 10$)		Group 2 ($n = 33$)		Group 3 ($n = 8$)	
	M	SD	M	SD	M	SD
Devising classes	2.30	0.68	2.48 [1]	0.63	3.38	0.52
Preparing activities	2.60	0.52	2.72 [2]	0.63	3.53	0.54
Organizing groups	2.60	0.52	2.63 [3]	0.67	3.38	0.52
Using TBL/PBL	2.33 [4]	0.50	2.44 [2]	0.56	3.50	0.54
Assessing learning	2.38 [5]	0.52	2.50 [3]	0.73	2.75	0.71

[1] $n = 31$ [2] $n = 32$ [3] $n = 30$ [4] $n = 9$ [5] $n = 8$

Note: Group 1: attended 0 FD events
Group 2: attended from 1 to 5 FD events
Group 3: attended more than 5 FD events

Differences in scores on each item between the three groups were examined using Kruskal-Wallis Tests. Tests were conducted for each item, and so a Bonferroni correction was applied, with all effects are reported at a .01 level of significance. The tests revealed a significant difference in scores between the three groups for Item 1, χ^2 (2, $n = 49$) = 11.65, $p = .003$, Item 2, χ^2 (2, $n = 50$) = 9.58, $p = .008$, and Item 4, χ^2 (2, $n = 49$) = 15.00, $p = .001$. Results for Item 3, χ^2 (2, $n = 48$) = 8.01, $p = .018$, were significant only at the uncorrected level of $p < .05$, while results for Item 5, χ^2 (2, $n = 46$) = 1.28, $p = .528$, were not significant. The result for Item 5 is most likely due to the fact that means for this item were substantially lower for Group 3 than means on Items 1- 4 for this group. This strongly suggests that even among those faculty members who have attended multiple AL-focused FD events, assessing learning in this teaching methodology remains an issue.

To further examine these differences between groups, follow-up Mann-Whitney U tests were used to compare scores between groups. In order to reduce the degree of correction necessary, only comparisons between Groups 3 and 2 on Items 1, 2

and 4 were conducted. As means on all items for Groups 2 and 1 were quite close, it was considered that no, or at best a very small, significant difference would be found in these scores. Furthermore, as means for Group 1 were lower than those for Group 2 across all items, any significant difference between Groups 2 and 3 would also more than likely apply to the difference between Group 1 and Group 3 as well. In total, three tests were conducted with Bonferroni correction applied and a corresponding .0167 level of significance. The tests revealed significant differences between Group 3 and Group 2 on all three items. For Item 1 (U = 40.5, z = -3.186, p = .001), there was a large effect size (r = .51; Cohen, 1988), while there was a medium effect size for Item 2 (U = 52.0, z = -2.832, p = .005, r = .44). For Item 4 (U = 30.0, z = -3.643, p < .001), there was a large effect size (r = .58) for this item as well.

4.4 Use of AL in the Classroom: Approaches, Activities and Issues

Faculty members were asked to report their use of AL in the classroom, taking the 2019 academic year as an example. This section will consider the approaches and activities faculty members employed in their classrooms, as well as the issues they faced.

When considered as a whole, the responses show a large proportion of faculty members (almost two-thirds) using AL in their classes during the 2019 academic year (Table 4). However, over one-third reported not using AL in their classrooms during 2019.

Table 4. Use of AL in the classroom (2019)

Use by	Yes	No
All respondents (n = 51)	33 (64.7%)	18 (35.3%)
Group 1 (n = 10)	4 (40.0%)	6 (60.0%)
Group 2 (n = 33)	21 (63.6%)	12 (36.4%)
Group 3 (n = 8)	8 (100%)	0 (0.00%)

Note: Group 1: attended 0 FD events
Group 2: attended from 1 to 5 FD events
Group 3: attended more than 5 FD events

As might be expected from the results reported above, when faculty members are broken down into groups based on FD participation, the trend in results suggests that a larger proportion of faculty members who have attended FD events used AL in their classrooms, and in this sample, the proportions increased from 40% among non-attendees to over 60% for those have attended between 1 and 5 FD events, and up to 100% for those respondents who attended more than 5 events.

The fact that a large number of teachers have not used AL, and the fact that among these teachers are many who have taken part in FD events, makes clear a visible gap between the current situation and the aims of MEXT's reforms. It also points to the need for continuing FD, even in institutions where AL-focused FD has been emphasized. One possible form that this FD could take will be suggested in the discussion below.

In addition to reporting whether or not they had used AL in the classroom in 2019, faculty members were also asked to provide examples of how they used AL, and the issues they faced when doing so. A summary of these responses will be reported in this section in order to provide context to the results reported above.

Thirty-four of the 52 faculty members who responded to this survey said they used AL in 2019, and of these, 32 provided a description of how they used AL in their classrooms. Table 5 presents the categories that emerged from the content analysis of these descriptions. Many faculty members mentioned two or more categories and thus there was a degree of overlap in the coding of the data.

Table 5. Categories and instances from faculty responses on use of AL in the classroom

Category	Instances
Group-based activities	15
Problem Solving	9
PBL/TBL	8
Discussion	6
Presentation	4
"Real-world" connection/experience	4
Miscellaneous other (e.g. active lecture, self-direction)	8

By far, the most often mentioned way in which faculty members implemented AL in the classroom, was that of group-based activities, and these included a range of forms, including peer learning, research activities, problem solving, and discussion in groups. In fact, the group-based activities category overlapped prominently with a number of the other categories listed in Table 6, such as problem solving, PBL/TBL, and discussion, and thus it would not be an exaggeration to say that the vast majority of reported uses of AL in the classroom were group-based. Not all mentions were related to the use of groups. Several descriptions of PBL and problem solving, as well as that of self-direction, concerned students working individually.

Two other areas deserve mention. The first of these is the "real-world connection" category. The activities described in these responses seemed to be addressing one of MEXT's aims in introducing AL to universities, as they often focused on developing the skills students would need in their future professions. The second is the single mention of active lecturing. This AL technique is often mentioned as a means for faculty who have become accustomed to delivering lectures to gently transition into a more active learning mindset. The fact that at least one faculty members is using this technique in their classes is a good sign, but it also raises the question of whether others are using it as well, or if they know of it, and if so, why they are not using it as well.

Of the 32 faculty members who described how they used AL in their classrooms, 27 provided examples of the issues they faced in implementing AL in this context. Table 6 presents the categories that emerged from the analysis of these responses. As before, many faculty members mentioned two or more categories in their responses, creating overlap between the categories.

Table 6. Categories and instances of issues faced in using AL in the classroom

Category	Instances
Group-work	17
Assessment	12
Student motivation	4
Student abilities and knowledge	4
Large class size	3
The need for more time	3
Student awareness	2
Miscellaneous other (e.g. support, surface learning)	3

Issues with the two areas of group work and assessment dominate the issues reported. Student-related issues such as motivation, ability, knowledge and awareness form a large bloc as well. In addition, two commonly reported issues with AL (e.g., Patrick et al., 2016) large classes (3) and the need for more time when using AL (2) were also mentioned. The overlap between the categories was quite noticeable. Several responses mentioned the difficulties of assessing individual contributions in groups, or of the differing levels of motivation that can make groups function less effectively.

On the basis of the responses in this data set, the two primary issues faced by STEM faculty members are related to organizing groups and assessing student learning in AL activities and approaches. The issues with assessment echo the finds above with regard to faculty members' confidence levels, and this evidence would suggest that this area, together with group-based activities, should figure

prominently in any future AL-focused FD activities.

5. Discussion

The purpose of this study was to clarify the current situation of AL implementation among university STEM educators, by asking how familiar university educators are with AL, how much FD they have taken part in, and how well they understand basic principles of AL, as well as how confident they are in their ability to implement AL, how they are using AL and what issues they perceive in when using AL in their classrooms. Survey responses from 52 faculty members from the authors' university indicated that faculty members have a decent familiarity with AL, and that a majority have attended AL-focused FD events. In addition, a majority of faculty members expressed either a reasonable or a good understanding of basic AL principles. Responses also indicated that, when taken as a whole, the faculty members who took part in the survey have a degree of confidence in their ability to devise AL-based classes, prepare AL activities, organize group-work, employ TBL/PBL and assess AL. A majority of faculty members used AL in their classrooms during the 2019 academic year, and the major forms that this took were, group-based activities, problem solving, TBL/PBL, discussions and presentations, and "real-world" experiences. The most prominent issues reported by faculty members when using AL in their classrooms were organizing group work and assessing student learning.

Before discussing the implications of these results, several points should be noted. First, in regards to the use of AL, over 60% of respondents indicated that they used AL in their classrooms in 2019. While this is a positive result, and may be a result of the emphasis on AL-based FD as a result of the AP Program, it is lower than the proportion of STEM faculty members using AL (80%) reported by Patrick et al. (2016) in a study with a similar sized sample at a large American university. One reason for this may be the relatively recent introduction of AL to Japanese universities, when compared to those in America.

Second, respondents mentioned a variety of AL approaches and activities that they employed in their classrooms. The majority of the categories listed above in Table 6 map quite well onto the examples of effective AL methods mentioned in MEXT's (2012) characterization of AL: "discovery learning, problem-solving learning, experiential learning, investigative learning,... group discussions, debates and group work in the classroom," (p. 37). That faculty members are using a range of AL methods in the classroom is commendable, but the close resemblance between the activities reported by faculty members and those listed by MEXT, brings to mind again Tsumochi's (2016) observation, cited in the literature review section, that many educators consider the use of student-centered methodologies as fulfilling the need to implement AL, without giving full thought to how AL can be used to promote student learning. Whether this reflects the current situation of the teachers in this study is outside the range of the data collected in this pilot study, but it does suggest that investigating faculty members' rationales behind their use of AL in the classroom is an important area for future research.

Third, analyzing responses on the basis of the number of FD sessions participants attended revealed a general trend of better understanding, higher confidence in abilities and greater use of AL together with greater participation in FD. In regards to faculty members understanding, the findings, while seeming to indicate that there is a relationship between greater exposure to AL-focused FD and a better understanding of basic AL principles, should be interpreted with a degree of caution.

First of all, as one aim of the larger study was to investigate respondents' conception of AL, no definition of AL or characterization of its basic principles was given to participants, and for this reason, respondents may not have all been considering similar principles when answering this question. Secondly, as the sample in this study is one

of convenience, it may be difficult to separate out the effect of FD on faculty members' professional development from possible predispositions towards professional development and new forms of pedagogy in those individuals who took part in a greater number of FD events.

The above results raise a number of areas to be investigated in future research. For those faculty members who have not attended FD events, the question of why they have not and how to remove any obstacles to their participation, such as time constraints (Gregory & Martindale, 2016), need to be clarified. Conversely, for those educators who have attended FD sessions, but who are not using AL at the present time, a better understanding of their rationales for not using AL, or the barriers they see preventing them from using AL in their courses is required.

With the above caution in mind, nonetheless, analysis of faculty members' degree of confidence in five areas of using AL in the classroom, would also seem to provide evidence for the positive effect of FD on teachers' perceptions of their own abilities. There remain however, issues, such as the assessment of learning, where further FD seems to be called for.

Interestingly, faculty members expressed a limited degree of confidence in their ability to assess learning, and this was reinforced by the prominence of assessment in the issues mentioned by faculty members. Another prominent issue mentioned was that of organizing group work. However, faculty members expressed a much higher degree of confidence in their ability to do this than in their ability to assess learning. This suggests that there may be a discrepancy between perception and practice and that there is a need for greater investigation into this discrepancy as well as whether a similar discrepancy exists in the other areas as well.

Taken overall, the results of this study reflect positively on the current state of AL implementation among STEM educators at the authors' university, and reflect the efforts that have been made of the past five years as the university took part in the AP program. However, the study also revealed that a gap still remains between the current situation and the realization of MEXT's aims in practice. Specifically,

- Over two-thirds of respondents reported that they did not use AL in their classrooms during 2019;
- Between 30 and 50% of respondents expressed a limited degree of confidence in their ability in regards to five areas related to using AL in the classroom;
- 45% of respondents expressed a limited understanding of basic AL principles;
- Almost 20% had not attended AL-focused FD events

The existence of this gap would seem to indicate the need for further AL-focused FD activities. However, traditional teacher development activities, such as workshops or seminars, present a number of limitations. First of all, they tend to take place at scheduled times in particular places, which makes it difficult for many faculty members to attend. This is an important factor considering the present Coronavirus pandemic, where faculty members may be forced to not only teach, but also engage in FD activities from remote sites off campus. In addition, as Elliot et al. (2015) noted, insufficient time is a significant obstacle for faculty members who wish to take part in FD, and therefore faculty members prefer to have asynchronous alternatives. Elliot et al. further note that many successful FD programs allow for flexibility and self-pacing by participants. One possible means to address these limitations would be to move FD activities into an online environment.

In addition to the limitations of time and place, traditional FD activities have a further drawback—they are not always effective means in changing teachers' ideas about teaching and adopt new teaching practices (Guskey, 2002). Drits-Esser & Stark (2015) argue that for the purpose of improving teachers' professional development, a shift in agency is required — a move "away from programs that focus on creating change in teachers" to activities

that focus on "providing opportunities for active engagement, influencing teachers to take responsibility for their own learning and to reflect on their practice," (p. 1). In the Japanese context, Komatsu (2016) has expressed a similar sentiment, stating that to better employ AL in the curricula, educators need to become more active learners themselves. A shift towards online FD activities could respond to this need as well.

In their review of the literature on online FD, Gregory and Martindale (2016) note that online FD resources can provide faculty members with opportunities for active engagement in learning. In particular, they note that task-centered FD resources, which are focused on strategies educators can apply in their own teaching, together with case examples for suggested use, can foster motivation and uptake among faculty members by linking resources to educators perceived needs. Courses that feature fully online FD resources, such as those offered by the Online Learning Consortium (https://onlinelearningconsortium.org), Quality Matters, (https://www.qualitymatters.org), or the K. Patricia Ross Academy (www.https://kpcrossacademy.org), have become increasingly popular outside Japan, However, such courses have yet to gain a foothold in Japan.

A final advantage that a shift towards online FD activities could provide is greater exposure to the educational potential of ICT technology, as well as some of the difficulties their learners will face, and the opportunity to encourage the development of basic online teaching skills.

In addition to clarifying the present situation of AL implementation among university STEM educators, this study found that participation in FD seemed to influence faculty members use of AL and their confidence in their ability to do so. Yet, as noted above traditional FD activities are not very effective in changing teacher's ideas about teaching. Given the positive results from the FD activities that have been carried out at the authors' university, a question could be asked as to how much more effective could other forms of FD, such as a move towards online FD, be in encouraging the implementation of AL.

6. Conclusion

This study has characterized the current situation at the authors' university with regard to faculty members' familiarity with AL, the understanding of its basic principles, their confidence in their ability to implement AL and their use of AL in both a classroom and online environment. The findings are based on a small sample of convenience, and this may limit the generalizability of the findings.

In addition to highlighting the progress that has been made, the results also highlighted areas of need, such as increasing faculty members abilities to assess learning in AL contexts, and the need for more training in organizing group work. The results also underline the need for continuing FD to support the implementation of pedagogical initiatives.

The survey that provided the data sets analyzed in this study focused on the aforementioned areas. Further research in this area is needed to investigate the reasons why some faculty members have not attended FD events, and among those who have attended AL-focused FD, why they have not used AL in teaching, as well as the reasons why faculty members lack confidence in their abilities to implement AL. Such information could help to uncover the obstacles that are currently impeding implementation of AL, and thereby, aid in the development of more effective FD activities.

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