

Pioneering research on the contribution of astronomy to the needs of older adult learners

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In recent years, mainly in developed countries, there has been a significant increase in healthy lifespans as a result of advances in healthcare. For older adults, learning is important in improving their quality of life. However, previous research on lifelong learning for older adults has not covered science subjects, including astronomy, as learning subjects. Thus, this study investigates the contribution of astronomy to the needs of today's older adult learners. Based on the findings, and contrary to classical studies about learning for older adults based on research in the 1970s, present older adult learners who focus on astronomy are: 1) not looking for practical benefits from their learning; 2) not attempting to make new friends or reflecting on their past lives; and 3) simply enjoying learning itself and aiming to broaden their perspectives through learning. These findings imply that the community of astronomy communication should contribute to older adult learners by adapting various strategies to their needs and characteristics.

Introduction

In recent years, especially in developed countries, the population has been rapidly ageing, and opportunities for lifelong learning among older adults have been increasing (Hori, 2001; Withnall, 2009; Cabinet Office of Japan, 2021). In this regard, there has been growing research on education and learning for older adults. However, studies on lifelong learning among older adults in natural sciences, such as astronomy, have not made significant progress. Researchers have only recently recognised the differences between older adult learning and learning for the younger generation. In particular, there has been limited research on why and what older adults choose to learn (Kim & Merriam, 2004).

As for lifelong learning, especially for older adults, typical needs include: 'satisfying curiosity', 'confirming and maintaining relationships with others' and 'preparing for coming decline and death' (McClusky, 1971). These findings contrast the learning needs of school students, who typically aim to 'prepare for life' and 'adapt to future social life'. In addition, this differs from adult learning, which typically focuses on real-world applications, such as job skill acquisition and obtaining licenses and certifications. In addition, older adults have the advantage of using their past experiences in learning. Conversely, due to their physical and mental decline, it is not

necessarily a good idea to use the same teaching materials and methods as those for younger generations.

Thus, the present study investigates the contribution of astronomy to the needs of older adult learners. As a first step, we clarify what older adult learners might need from astronomy. We then suggest informal learning programmes that not only highlight this subject's importance but also meet the needs of this demographic.

Current status of research on lifelong learning for older adults

Current status of lifelong learning in developed countries

Healthy lifespans have been increasing annually, especially in developed countries. For example, according to a 2019 survey by the World Health Organization, life expectancy is 80.8 years (on average) in Organization for Economic Cooperation and Development (OECD) countries, while healthy life expectancy is 70.3 years (on average) in developed countries (see Figure 1). Additionally, Figure 2 shows the annual increase in Japan's average life expectancy and healthy life expectancy.

With the increase in healthy lifespans and the growing importance of careers for older adults, they must acquire social skills and new perspectives that can enable them to

effectively integrate into social activities after retirement. Older adults who have lost income and relationships due to retirement need to find new employment and/or new activities in their new communities. Withnall, (2009) argued that under these circumstances, through continuous learning, even older adults can achieve a higher level of *active ageing* (i.e. a state in which personal enjoyment, human connections and social contributions are all at a high level).

Retirement also causes older adults to lose the center of their daily activities. This results in significant changes in their physical, mental, and social lives. To cushion this shock, some kind of alternative activity to work is essential. The primary significance of learning for older adults is to reduce the problems of old age caused by such changes in the environment by continuing to engage in some kind of activity and keep developing themselves (Withnall, 2009). In recent years, research has suggested that the motivation for learning among older adults is not only in the context of personal development, but also within a societal/emancipation framework (Sibai & Hachem, 2021). In an environment without a retirement age and with limited financial support for older adults, it is considered necessary to continue career development and learning in old age to maintain a stable life. In addition, in environments where

discrimination and stereotyping against older adults (especially women) exist, learning can enhance social justice and participation. However, we will not discuss this aspect in depth in this article.

In recent years, the number of older adult learners has been increasing. More than half of older adults in developed countries have engaged in some type of learning activity, with the majority planning to

continue learning in the future (Withnall, 2009; Cabinet Office of Japan, 2019). In this situation, the conventional idea that human life is divided into three stages (i.e. school age, adulthood and old age) has become an anachronism. Instead, it has been suggested that there is a new third stage between adulthood and (declining) old age: a “time when people are retired, but still have the energy to enjoy their lives” (Withnall, 2009, pp. 9-11).

Theories of lifelong learning

Research on lifelong learning for older adults has been conducted from both a social welfare perspective and an overall learning perspective. Moody and McCluskey were pioneers in theorising lifelong learning in the 1970s. Separately, they investigated how older adults’ lives and experiences influence their perspectives on learning. Before their work, researchers recognised that adult education was different from educating children: in the 19th century, the term “andragogy” – the theory of learning for adults, just as pedagogy is for children – was already in use (Jarvis, 2010). However, in the 1970s, there was a push to understand learning in older, retired adults. In this context, Moody and McCluskey both challenged the conventional belief that older adults do not need education. In particular, Moody considered that education is necessary for the self-realisation of older adults and that lifelong learning is based on their need to “transcend” – to overcome past roles and self-definitions. He also argued that their plentiful life experiences can be effectively applied to learning in the sense that they can learn by referencing their own lives (Moody, 1990).

On the other hand, McCluskey argued that learning is the driving force in the development and growth of all human beings, including older adults, and advocated that the needs of older adult learners are rooted in *stabilising margins* (McCluskey, 1971). In this case, margin refers to the excess of power (ability) overload (burden). In old age, power decreases as income and physical/mental health decline. Meanwhile, the overall margin decreases as the load increases due factors such as to rising prices and increased family responsibilities. McCluskey argued that education is important for readjusting the margin of power to such loading. Especially among older adults, the transcendent need becomes more significant to overcome physical/mental decline constraints. According to *Moody (1990)*, learning about human history allows older adults to find themselves in history, and learning about psychology and literature will enable them to objectively look at the struggles common to all of life and see that human life is one story. Hence, history, classical literature, religion and other themes related to eternity are popular subjects in lifelong learning.

From the perspective of gerontological sociology, it has been proposed that the theme of ‘connectedness’ exists in the needs of older adult learners. Such needs are based on the tendency that as people age, the weight of their desires and social needs shifts from *achievement needs* (the need to achieve goals) to *affiliation needs* (the need to enrich human relationships). With the increasing weight of older adults’ need to cope with loss in old age, rebuilding relationships is an important issue. Thus, the need for connection should be the foundation of lifelong learning (McCluskey, 1990; Hori, 2001; Murahashi & Morita, 2015).

Additionally, a relatively well-accepted theory of lifelong learning is the need for a life review (reflecting on one’s own life), as studied by *Lowy and O’Connor (1986)*. A life review is a universal mental process that naturally occurs in the later stages of life. It has also been suggested that doing this can help reduce stress and improve the quality of life of older adults (Merriam, 1990; Hori, 2001).

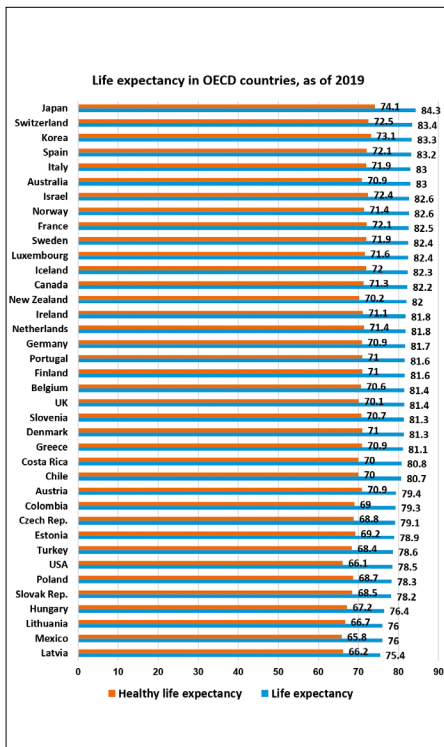


Figure 1: Life expectancy and healthy life expectancy in OECD countries, as of 2019. Note: The data used for this figure were taken from World Health Organization (n.d.)

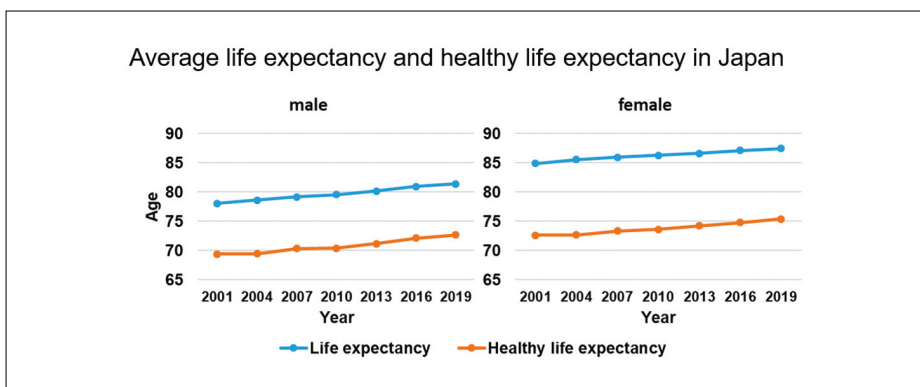


Figure 2: Annual increase in average life expectancy and healthy life expectancy in Japan. Note: The data used for this figure were taken from Cabinet Office of Japan (2021).

Londoner argued for the theories of *expressive* and *instrumental needs* as a different approach (Londoner, 1990; Kim & Merriam, 2004). The former refers to the need to enjoy learning, while the latter represents the need to obtain something as a result of learning. As people age, their lives can become unstable for physical and/or financial reasons. In such situations, learning activities are based on *instrumental needs*. Since participation in learning based on *expressive needs* only becomes possible after their lives have become stable, it has been argued that learning should be based on *instrumental needs*, especially in the later stages of life (Londoner, 1990). In traditional pedagogy and andragogy, the *expressive* need to acquire skills needed in social life was important (Jarvis, 2010). Also, early gerontology focused on the *expressive* needs of coping with decline. One of the major research questions in this study is whether this is also true for older adults today.

Learning for older adults in today's world

The aforementioned theories of lifelong learning include several problems. Foremost among them is that the majority of these theories must be updated. Fifty years have passed since the first articles on lifelong learning were published, and healthy lifespans have dramatically increased, especially in developed countries. Thus, it is no longer appropriate to consider retirement as a withdrawal from society. Instead, we must consider that there is still a free and healthy period after retirement (Hori & Cusack, 2006). In today's world, healthy older adults value learning based on expressive needs more than the desire to cope with decline.

Second, although there have been several surveys on the needs of older adult learners, most of them did not assume that older adults might study astronomy or other science-related subjects. Since the starting point of lifelong learning theory is to deal with physical and/or mental decline, it is not surprising that astronomy might be inappropriate as a learning objective. However, as noted earlier, older adults have greater learning opportunities for enjoyment (Kim & Merriam, 2004). In such a context, astronomy could become a significant component of learning for older adults (Impey & Buxner 2020; Pompea & Russo, 2020).

In this regard, it has been pointed out that although older adults benefit from education, most education programmes for older adults are only designed from the perspective of the education provider. Moreover, the learning activities are not necessarily academic in nature; they include topics that range from hobbies and healthcare to economic savings. Thus, without research into the needs of older adult learners, it is impossible to construct educational designs that genuinely benefit older adults (Withnall, 2009).

Astronomy education has contributed to motivating and broadening the horizons of countless learners in school and adult education (Pompea & Russo, 2020). Applying such education to older adult learners may be considered a natural extension of astronomy education. Conversely, identifying the differences between the learning of older adults and that of younger generations, especially regarding their learning needs, is unavoidable. As a first step, this study focuses on the learning needs of older adults and examines the position and future of astronomy in this demographic.

Survey of the learning needs of older adults

In the previous section, we reviewed the learning needs of older adults based on current literature. Some of them are also appropriate for younger learners. However, transcendent needs and the need for connectedness are particularly evident in older adults. Thus, providing education in areas that address these needs could lead to greater satisfaction for older adult learners. Astronomy, which deals with the eternity of time and space, may meet their transcendent needs, although its relevance remains unclear.

This is not the first survey on the learning needs of older adults. For example, a survey conducted in Osaka (1998–1999) investigated the preferred learning subjects of older adults. Hori and Cusack (2006) compared this survey with a related one conducted in Vancouver in 2003. The results showed that various subjects, such as 'History and Culture of the Community', 'Current Topics (Economics, Politics)', 'Literature, Classics', 'Practical Information about Healthy Ageing' and 'Gardening,

Potteries' were popular in Japan, while 'Volunteer Activities' and 'Activities Involving Communication with Other Seniors' were popular in Canada.

However, it should be noted that while the preferred learning subjects were examined in a multiple-answer format in these surveys, 'Natural Science' was not included as an option. In other words, these surveys assumed that older adults do not want to learn natural science, including astronomy. Unsurprisingly, the learning trends derived from such surveys do not match those of natural science. However, as discussed later, many older adult learners prefer to learn about astronomy and other science-related subjects. This indicates that there are unknown learning needs related to astronomy and natural science that have been overlooked in previous research.

Based on the assumption that older adults also have the need to learn astronomy and natural science, this study examines the demographics of older adults who prefer to learn astronomy and discusses the contributions that the astronomical education community can provide in the context of lifelong learning.

Questionnaire survey

To investigate the learning needs of older adults and their connection to astronomy, we surveyed a sample of participants in five educational courses for older adults held in Japan between October 2020 and July 2021. One of the courses was a specialised lecture on astronomy, to which 22 participants responded (mean age 73.7 years; standard deviation (SD) 5.5 years). In addition, three were omnibus courses in various fields, each of which included at least one lecture on astronomy. Overall, 59 participants responded in these three courses (mean age 76.0 years; SD 6.5 years). The remaining course was unrelated to natural science (psychology), yielding 24 responses (mean age 72.5 years; SD 6.3 years).

Surveys with incomplete or missing data were excluded from the analysis. The age and gender of the respondents in the present study are shown in Table 1. In this type of survey, a sample size of 200 to 400 can be considered reliable, depending on the statistical method used. The sample size here is 105 (73 valid responses), which is a little below this level but still somewhat reliable.

	~59	60-64	65-69	70-74	75-79	80-84	85~	Unknown
Male			6	18	4	9	1	
Female	1	2	4	17	2	3	1	2
Unknown								3

Table 1: Age and gender distribution of the participants

Survey items

The survey questionnaire in this study focused on the (1) motivation for learning and the (2) preferred learning subjects, in addition to items describing the attributes (e.g. gender and age) of the participants and the reasons for taking the course. In the following, we discuss the relationship between the learning needs of older adults and astronomy based on the aspects mentioned above.

Motivation for learning

A total of 15 items were selected regarding the motivation for learning (see Table 2). The participants were asked to rate each item on a four-point scale: 1: 'Not at all applicable'; 2: 'Not very applicable'; 3: 'Somewhat applicable'; and 4: 'Very applicable'. Nine items were created as the *Enjoyment of Learning Scale*, which is in line with previous research (Asano, 2006). These items consisted of three sub-scales: 'Practical Enjoyment' (three items), 'Enjoyment of Broad Variety of Thinking' (three items), and 'Enjoyment of Knowing' (three items), respectively. In addition, we used six items from the *Motivation to Learn Scale*, which qualitatively categorised the learning needs and characteristics of older adults (Murahashi & Morita, 2015).

Preferred learning subjects

The 17 items used in the surveys in Japan and Canada were used as a basis (Hori & Cusack, 2006). However, since these surveys had no science-related items, we prepared three additional items, including 'Astronomy', 'Natural Science' and 'Philosophy, Ideology, Religion'. These 20 items are shown in Table 3. The respondents were asked to rate the degree of their interest in these areas on a four-point scale: 1: 'Not at all interested'; 2: 'Somewhat interested'; 3: 'Rather want to learn'; and 4: 'Would definitely like to learn'.

Results

Mean values for each scale and scores for each item

Table 2 presents the aggregated results for the (1) motivation for learning. When considering

the *Enjoyment of Learning Scale* among the question items, the mean values for 'Enjoyment of Broad Variety of Thinking' and 'Enjoyment of Knowing' were relatively high. In contrast, the mean value for 'Practical Enjoyment' was

relatively low. Statistical tests were also conducted using a one-factor analysis of variance to determine whether there are significant differences between the sub-scales of the *Enjoyment of Learning Scale*. The main effect was significant ($F(2,112) = 128.50, p < .001$), indicating that there was a significant difference among the groups being compared. In this notation, 'F' refers to the ratio of variance between groups to variance within groups. At the same time, the numbers in parentheses represent degrees of freedom for the numerator (2)

Items	Mean	SD
Practical Enjoyment $\alpha = .85^*$	2.43	(.76)
I enjoy learning because it relates to my work, activities and life	2.32	(.86)
I enjoy it because what I learn is useful in my work and life	2.40	(.81)
I enjoy learning because I can use what I have learned in real life	2.59	(.93)
Enjoyment of Broad Thinking $\alpha = .86$	3.32	(.60)
I am happy that my learning enables me to think in a variety of ways	3.26	(.75)
I am happy that learning enables me to have a broader perspective	3.33	(.65)
I enjoy learning about different ways of thinking	3.38	(.64)
Enjoyment of Knowing $\alpha = .88$	3.50	(.55)
I enjoy increasing my knowledge	3.53	(.63)
I enjoy knowing even one thing	3.45	(.65)
I am happy when I gain new knowledge	3.51	(.58)
I want to learn proactively	3.33	(.71)
I want to enjoy study itself	3.34	(.65)
Learning Motivation Scale (Murahashi & Morita, 2015) $\alpha = .85$		
I want to expand my perspectives	3.40	(.62)
I want to utilise learning in daily life	2.84	(.87)
I want to connect with others	2.62	(.79)
I want to think about the meaning of life	2.89	(.86)

* The reliability coefficient α is an index used to assess the consistency of items within a scale. Generally, higher α values indicate that items within the scale are related, suggesting higher reliability of the measurement method. When α exceeds 0.70, the consistency is considered sufficiently high, and it is deemed acceptable to create a composite variable.

Table 2: Means and standard deviations for each of the two scales regarding the reasons for learning ($N = 73$)

and denominator (112), respectively. Then, multiple comparisons using the Bonferroni method showed differences between all sub-scales. The Bonferroni method is a statistical technique used to adjust significance levels when performing various comparisons, ensuring that the overall risk of falsely identifying differences is controlled. Specifically, 'Enjoyment of Knowing' had the highest score, followed by 'Enjoyment of Broad Variety of Thinking'.

In contrast, 'Practical Enjoyment' had the lowest score. On the *Motivation to Learn Scale*, relatively high scores were found for items such as 'I want to proactively enjoy what I choose to do', 'I want to enjoy studying itself' and 'I want to broaden my perspective through learning'. Conversely, scores were relatively low for items such as 'I want to connect with others through learning' and 'I want to utilise learning in daily life'.

For the older adults surveyed in this study, which included many participants in astronomical courses, the results suggest that the enjoyment of learning was more important for choosing the learning content compared to applying the learning content to their daily lives. However, the enjoyment of learning score was also comparatively high among the psychology course participants.

We then looked at the mean values for each item concerning the (2) preferred learning subjects. Table 3 presents the average of the responses based on their interest in learning about the 20 subjects. Compared with the average, 'Natural Science' and 'Astronomy' had the highest values, followed by 'Current Topics' and 'History and Culture'. The same applies when comparing the number of respondents who answered 'definitely want to learn' or 'rather want to learn' as an option.

This result seems unsurprising since the population mainly consists of participants attending courses in 'Astronomy'. Yet, when the population was restricted to psychology courses and general education courses for comparison, the highest-rated items were 'Philosophy, Religion' (3.26; SD.64), 'Current Topics' (3.22; SD.74), 'Natural Science' (3.22; SD.83) and 'History, Culture' (3.11; SD.74). Even when the participants in the astronomy and

Learning Subject	Mean	(SD)
11_Natural Science	3.40	(.74)
12_Astronomy	3.26	(.76)
6_Current Topics (Economy, Politics)	3.16	(.74)
8_History and Culture of the Community	3.16	(.68)
7_Computers	3.11	(.82)
9_Hobbies	3.11	(.77)
20_Philosophy, Ideology, Religion	2.92	(.89)
10_Literature, Classics, Book Discussion	2.92	(.75)
13_Gardening, Pottery	2.88	(.96)
14_Arts, Painting	2.86	(.87)
3_Physical Fitness	2.84	(.72)
5_Practical Information about Ageing	2.77	(.82)
1_Volunteer Activities	2.67	(.68)
2_Activities Involving Communication with Other Seniors	2.56	(.72)
4_Day Trip	2.56	(.81)
15_Traditional Crafts	2.48	(.99)
18_Activities with Old Movies and TV programmes	2.42	(.77)
16_Activities Involving Communication with Students	2.40	(.87)
19_Life Review	2.36	(.87)
17_Activities Involving Communication with Children	2.31	(.83)

Table 3: Preferred learning subjects (N=73)

science courses were excluded, there was evidence of high learning needs in 'Natural Science'. 'Astronomy' (2.85; SD.80) also received more interest than the average for all items (2.81). This indicates that learning about natural science is a certain need among older adults in general, especially those with diverse interests (Karino & Agata, 2009; Karino & Otabe, 2022). It should be noted that these results were obtained in Japan, and there is no guarantee that they will be the same in other developed countries. A comparison between Japan and Canada in a previous study reported some differences (probably based on the difference in their learning circumstances) between the two countries (Hori & Cusack, 2006).

Analysis of the learning needs of older adults with a preference for astronomy

The results above were used to explore what motivates older adults to prefer learning astronomy and natural science. To compare with other typical subjects of lifelong learning, the preferred subjects in question (2) (i.e. motivation for learning) were first merged into six groups, based on the responses. A cluster analysis using the Ward method was then conducted for grouping, which are shown in Figure 3 and Table 4.

The items 'Astronomy' and 'Natural Science' were formed as an independent group

(Cluster F). The characteristics of each group from the correspondence analysis are also presented in Table 4. According to the two-dimensional plot of the learning subjects, Cluster F is located in a different area from the other groups, which is highly academic and distant from everyday life (Karino & Otabe, 2022). To investigate what motivated older adult participants who indicated a preference for Cluster F, which includes 'Natural Science' and 'Astronomy', we took the average scores of the answers in question (2) for each cluster. We performed a correlation analysis with the answers in question (1) (i.e. Preferred learning subjects).

Among the learning motivations, we examined the correlation between the *Enjoyment of Learning Scale* and each group. The results are shown in Table 5 and Figure 4. Focusing on the correlation between the *Enjoyment of Learning Scale* and Cluster F, including 'Astronomy', the correlation with 'Practical' was low. In contrast, the correlation with 'Thinking' and 'Knowing' was slightly higher. However, there were no significant differences compared to the other clusters. In terms of traditional subjects of lifelong learning (i.e. Cluster B, including 'Hobbies', 'Gardening, Pottery', 'Arts, Painting', 'Traditional Crafts', etc.), those who preferred Cluster B showed an overall high correlation with all of the enjoyment scales, especially in the enjoyment of having a broader perspective. The group that preferred Cluster C (i.e. activities related to socialising with other older adults and activities related to their lives) also had higher overall scores across all enjoyment scales. Moreover, the group that chose Cluster A (e.g. interactions with the younger generation and volunteering) had a high

correlation with 'Practical Enjoyment'. In contrast, the other items were low, showing an opposite trend to Cluster F (which includes 'Astronomy').

The horizontal axis represents the "distance" between subjects. The closer the subjects are to each other, the more they are connected on the left side. In this study, the

Cluster	Learning subjects included		Learning oriented	Daily-life oriented
A	1_Volunteer Activities	16_Activities with Students	Low	Low
	17_Activities with Children	18_Movies and TV programmes		
B	9_Hobbies	13_Gardening, Pottery	Low	Middle
	14_Arts, Painting	15_Traditional Crafts		
C	2_Activities with Other Seniors	3_Physical Fitness	Middle	High
	4_Day Trip	5_Practical Info about Ageing		
	19_Life Review			
D	8_History and Culture	10_Literature, Classics	Middle	Middle
	20_Philosophy, Religion			
E	6_Current Topics	7_Computeres	High	Middle
F	11_Natural Science	12_Astronomy	High	Low

Table 4: Results of the cluster analysis

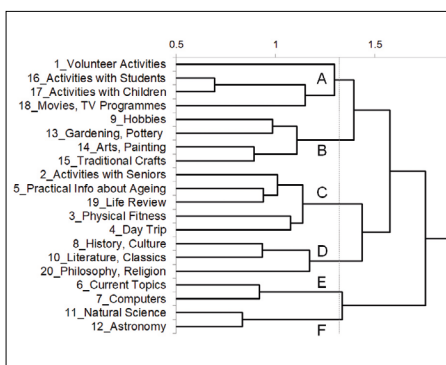


Figure 3: Results of the cluster analysis as a tree diagram.

Enjoyment of Learning		Groups of Learning Subjects					
		A	B	C	D	E	F
Practical	It relates to my work, activities and life	0.404	0.378	0.291	0.345	0.192	0.246
	What I learn is useful in my work and life	0.429	0.349	0.272	0.257	0.160	0.149
	I can use what I have learned in real life situations	0.397	0.455	0.429	0.338	0.271	0.184
Thinking	Learning enables me to think in a variety of ways	0.301	0.420	0.420	0.370	0.304	0.361
	Learning enables me to have a broader perspective	0.328	0.548	0.424	0.346	0.268	0.365
Knowing	I enjoy learning about different ways of thinking	0.221	0.257	0.355	0.222	0.239	0.360
	I enjoy increasing my knowledge	0.325	0.358	0.452	0.358	0.387	0.363
	I enjoy knowing even one thing	0.314	0.391	0.498	0.311	0.445	0.414
	I am happy when I gain new knowledge	0.218	0.224	0.360	0.385	0.255	0.362

Table 5. The correlation coefficients between the subject groups and the *Enjoyment of Learning Scale*

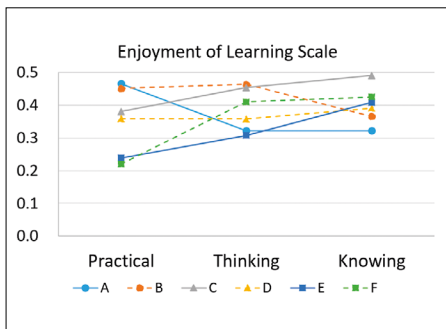


Figure 4: The correlation between the subject groups and the Enjoyment of Learning Scale. The graph shows which motivations are more closely associated with the preference of learners among the six study subject groups.

subjects are divided into six groups according to their similarities.

Conversely, the results showing the correlation between the *Motivation to Learn Scale* and each subject group are shown in Figure 5 and Table 6. Cluster F (which includes 'Astronomy') appears to behave peculiarly in these results. Specifically, Cluster F had the highest correlation with 'I want to enjoy study itself' and 'I want to expand my perspectives through learning'. In contrast, it had the lowest values for 'I want to utilise learning in daily life', 'I want to connect with others' and 'I want to think about the meaning of life'. When the other subject groups were considered, the correlation with 'I want to learn proactively' was low across all clusters. This suggests that for older adults, whether proactive or reactive, learning activities are not related to their chosen learning subject.

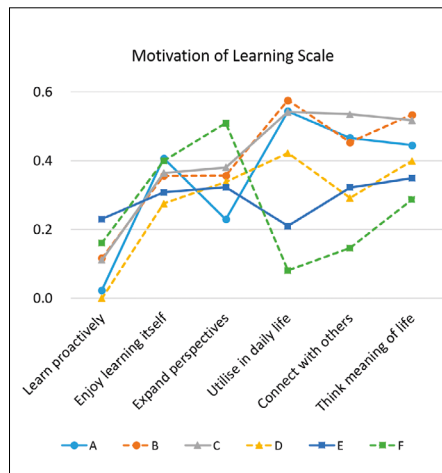


Figure 5: The correlation between the subject groups and the Motivation to Learn Scale. The representation is the same as in Figure 4. Group F, which includes astronomy, is more motivated to expand their perspectives than the other groups.

Even in the case of a relatively new survey conducted in Europe in the 2000s, most participants cited the 'desire to learn', 'maintaining an active spirit' and 'broadening perspectives' as their motivations for participating in learning activities. However, social reasons appeared to be less common. Furthermore, nearly half of the respondents answered that participation in learning was 'enjoyable', with many citing various motivations such as meeting new people and making friends (Withnall, 2009). The aforementioned survey suggests the existence of a 'third stage' of life consisting of retired but still active individuals with various learning needs (Hori & Cusack, 2006). The results of the present survey confirm these findings.

Motivation of learning	Groups of Learning Subjects					
	A	B	C	D	E	F
Learn proactively	0.024	0.117	0.112	0.000	0.231	0.161
Enjoy learning itself	0.407	0.356	0.364	0.275	0.308	0.400
Expand perspectives	0.230	0.356	0.381	0.338	0.323	0.509
Utilise in daily life	0.543	0.576	0.542	0.422	0.210	0.081
Connect with others	0.466	0.453	0.535	0.291	0.322	0.146
Think meaning of life	0.445	0.534	0.517	0.399	0.349	0.287

Table 6. The correlation coefficients between the subject groups and the Motivation to Learn Scale

Discussion

Learning needs of older adults

The results of the previous section show that older adult learners who prefer astronomy as a learning subject have the following tendencies:

1. They are not looking for practical benefits due to their learning.
2. The purpose of learning is not to make new friends or to reflect on their past lives.
3. They enjoy learning and want to broaden their perspectives through learning.

These findings indicate that the reason why older adult learners want to learn astronomy is not to recover from physical and/or mental decline, as pointed out in older adult learning theories (McClusky, 1971). Nor do they seem to be learning based on the need for connection or a life review, both of which were pointed out in previous studies (Merriam, 1990; Moody, 1990). Instead, when older adults study astronomy and natural science, they purely enjoy learning and the pleasure it gives them in gaining a broader perspective. The fact that they are not looking for practicality also indicates that older adults who prefer astronomy choose their study subjects based on their expressive needs (Londoner, 1990; Kim & Merriam, 2004). According to Londoner (1990), expressive needs are found among older adults whose environment does not require instrumental needs, which aim to fulfil the needs of everyday life. Additionally, this suggests that a segment of the population that does not require instrumental needs to readjust their margins (i.e. healthy and fulfilled older adults) tends to choose astronomy as the favoured option.

On the other hand, as seen in Figure 5, the characteristics regarding the preference for astronomy and natural science among older adult learners are distinct from traditional lifelong learning topics such as history and gardening. However, previous studies of learning theories for older adults have not considered the potential for this demographic to learn about natural science. This may be why these studies have failed to capture the need to derive enjoyment from learning and broaden their perspectives. In related research on educational programmes for older adults at universities, the top motivations for

participation were 'gaining knowledge', 'enjoyment of learning' and 'broadening perspectives' (Kim & Merriam, 2004), which are similar to those of the participants who preferred astronomy in the present study. The fact that the latter group does not fit into the traditional learning needs of older adults (e.g. margin-filling, connection-seeking, life review, *instrumental needs*, etc.) suggests that older adults who prefer natural science (including astronomy) may differ from the unique psychological situation of older adults that was perceived more than half a century earlier. Since that time, the healthy lifespan of older adults has considerably increased, while the thinking of older adults in retirement has significantly changed. Hence, it is not surprising that the needs of older adults back then would significantly differ from those of older adults today.

It is also possible that today's older adults may have increased their learning needs (including the need to recover margins and the need for connection and transcendence) as they age. To clarify this point, a broader survey is required to further examine the generational differences among this demographic.

As mentioned earlier, the learning needs of older adults are increasing as their healthy lifespans increase. In developing countries, where the older adult population is currently small, the importance of education for older adults will increase with future development. Providing educational opportunities for older adults is effective from a social welfare standpoint, e.g. protecting their health and preventing their isolation, and an educational standpoint, e.g. responding to their motivation to learn and improve their quality of life. An increased healthy lifespan will also mean more opportunities to support learning from the latter standpoint. Meanwhile, the astronomy education community should be able to make specific contributions as older adults have the motivation to learn about natural science.

Educational strategies for older adults

The University of the 3rd Age (U3A), founded in the 1960s, is said to be the pioneer of learning opportunities for older adults in Europe. This was due to the growing recognition of the importance of providing learning opportunities for older adults in the third stage of life, which is the period of self-realisation and self-fulfilment (Hori, 2001; Withnall, 2009; Jarvis, 2010). When the U3A

started in France as a summer school for retirees, it mainly utilised existing facilities, teaching staff and other resources of various universities. However, when the U3A movement spread to the United Kingdom, it began to employ local resources and have the participants run the activities themselves. In some cases, the learners became the teachers (Withnall, 2009).

The advantage of the French-type U3A is that the quality of education was kept above a certain level. On the other hand, the UK-type U3A had the advantage of encouraging the development of social skills among older adults. Additionally, the participants formed self-help groups where the members could learn social skills and health literacy from one another in the face of the common and inevitable challenge of *ageing*. The strong point of the latter type was that the participants could construct such communities of practice (Lave & Wenger, 1991; Withnall, 2009).

Now, let us consider the position of astronomy education in lifelong learning. Astronomy is a complex discipline that requires basic knowledge of mathematics and physics. It is also a field in which knowledge is rapidly updated due to ongoing developments in observations and simulations. In this regard, the UK-type approach includes some limitations compared to the French-type education of lifelong learning with the help of experts in the field. To provide satisfactory educational programmes based on the latter approach, it is helpful to have a common understanding on the side of the organisers/professionals as to what motivates older adult learners and what their needs are for astronomy courses.

In addition, astronomy is a field that is generally popular and is used as an important theme of STEAM (science, technology, engineering, the arts and math) learning due to its aspect as a multidisciplinary study that includes the ability to examine celestial objects, space and the physical universe (Karino & Agata, 2009; Pompea & Russo, 2020). It is also a field with a broad base in research methods, with multi-messenger observations of various electromagnetic waves, cosmic rays and gravitational waves, as well as simulations and theoretical studies. In the present study, we have shown a demand for astronomy among older adult learners and

that their learning needs are rooted in different areas than the traditionally considered needs of lifelong learning. In this context, it is necessary to consider what topics older adults are interested in, their needs, and what learning benefits can be achieved. Especially in developed countries, the older adult population will further increase, and the number of older adults who are potentially interested in learning astronomy will also increase. Reaching out to them will be an important topic for astronomy outreach.

Conversely, teaching methods must be considered in astronomy education for older adults, since there is no evidence that the educational methods used in classrooms and/or lifelong education are also effective in lifelong learning. School education, which aims to foster competencies for future life, and adult education, which intends to improve competencies for members of society, differ from lifelong learning regarding their goals and teaching materials (Hori, 2001; Jarvis, 2010).

In astronomy education, especially for students, the aim is to understand the natural environment in daily life (e.g. diurnal motion and seasonal changes), strengthen spatial awareness and understand nature (e.g. the origin of matter and the structure of the universe). For these purposes, planetarium projections, star parties, the use of remote telescopes and STEAM education are all helpful for understanding and deepening students' interests (Impey & Buxner 2020).

On the other hand, the primary goals of learning astronomy for older adult learners include satisfying their intellectual curiosity and enjoying learning. Some older adults may have commonsense knowledge of diurnal motion, seasonal changes, and so on. In addition, there is no content requirement in school education for the learning of older adults. Thus, significant changes in education strategies are necessary to satisfy their learning needs. It should also be noted that older adult learners may experience limitations such as reduced eyesight, decreased physical fitness and short-term memory (Kim & Merriam, 2004). Under such conditions, it is important to consider whether planetarium projections and nighttime stargazing events are as effective as those for younger

generations. In this regard, it is necessary to take into account different safety considerations and hold discussions about these points to make astronomy more inclusive for older adult learners (Ortiz-Gil et al., 2011; Impey & Buxner, 2020; Voelker et al., 2022).

Finally, older adults have the advantage that their experience and knowledge can be used as educational materials (Hori, 2001). For example, many older adults have viewed starry skies, meteor showers and bright comets in their youth. Such real-life experiences are a strong point and should be considered when exploring different teaching methods and strategies. Moreover, although the short-term intellectual capacity of older adults is typically in decline, compared to younger students, their ability to evaluate and make sense of certain aspects is thought to be more effective (Jarvis, 2010). Therefore, developing astronomy education materials for older adult learners that incorporate these strong points would be interesting.

Conclusion

In recent years, there has been a significant increase in healthy lifespans, mainly in developed countries. In this situation, learning plays an important role in improving the quality of life of older adults. Meanwhile, from the perspective of social welfare, providing learning opportunities for older adults can be effective in maintaining their health and preventing their isolation during retirement. In this regard, this study examined the learning needs of older adults to provide effective informal educational opportunities for this demographic.

Although there have been several studies on the learning needs of older adults, such research may not match older adults today. Specifically, such learning needs were based on the idea that older adults prefer to learn traditional subjects such as history, literature, healthcare, and gardening. Consequently, previous research on older adult learning did not consider science-related subjects like astronomy. However, astronomy, in particular, has drawn a certain level of interest among older adult learners. Hence, we also investigated the fundamental needs of older adult learners when choosing to study astronomy.

In the present study, a questionnaire survey was conducted to investigate the learning preferences of older adults. The results showed that the motivation to learn astronomy was not based on the traditional needs of lifelong learning. Instead, they chose astronomy to find enjoyment in learning. Meanwhile, they wanted to broaden their perspectives through learning. These findings indicate that such tendencies of older adult learners clearly align with *expressive needs* instead of *instrumental ones*.

In the future, providers of lifelong learning should specifically consider the needs of older adult learners and provide appropriate learning subjects. At the same time, in support of astronomy and other science-related subjects, it is necessary to consider educational methods that are safe, effective and satisfying based on their life experiences as well as their possible physical and mental decline. This study also intends to propose the participation of the astronomy education community in the field of lifelong learning, which is in line with the current situation. Doing so will not only be effective for the current population but also an investment in our future selves (Withnall, 2009).

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Biography

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